# LABORATORY AND FIELD EXERCISES IN PHYSICAL GEOGRAPHY



GILBERT H. TRAFTON

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BY

GILBERT H. TRAFTON, M.S.

INSTRUCTOR IN SCIENCE IN THE HIGH SCHOOL, PASSAIC, N.J.

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# PREFACE

Physical Geography has at last come to take its place among the other sciences as a subject which requires laboratory and field work for its highest development. The reasons for the introduction of laboratory methods in this subject are the same as those which demand its use in the other sciences, namely, the training which the pupil receives in the laboratory and the additional light thrown upon the subjects discussed in the class room. As Physical Geography is so generally assigned a place in the first year of the high-school course, it is of special importance that this first science should be so taught as to inculcate scientific methods of study.

But while the need of laboratory work is universally recognized by the leading educators, this adjunct has not yet found its way into the methods of the majority of our secondary schools. The causes we need not go far to seek. This newer feature of laboratory work in Physical Geography has been introduced in such comparatively recent years that there has not yet been sufficient time for schools and teachers to adapt themselves to the changed conditions. This is simply a repetition of what has happened in the development of the other sciences.

Another reason for the delay in introducing laboratory methods into many of our schools has been that, until very recently, there has been published no laboratory guide which could be placed in the hands of the pupils, such as had been prepared in the other sciences. Within the last

decade there have appeared enough suggestions to enable one to formulate a satisfactory laboratory course, but this material is so scattered that it requires some little time to collect it and a still longer time to put it into such shape that it may be used to advantage in the laboratory. These exercises are published with the thought that this difficulty may be partly overcome, and that those teachers who do not have the time to develop this subject from the very start may be saved much time and labor and be enabled to introduce laboratory methods into their courses earlier in their experience than they might otherwise do. And even for those who have already worked out their own laboratory exercises, it is hoped that these may prove helpful in their suggestions and in providing directions for the guidance of the pupil.

I take pleasure in making special acknowledgment of the kindness of Professor W. M. Davis. He has very kindly read over my manuscript, making valuable suggestions, and has allowed me to use plates and figures from his text-books. Some of the exercises included here were first suggested to me by his writings, as Exercises I and II; and the other exercises in his *Elementary Physical Geography* have also been suggestive in planning my outlines.

GILBERT H. TRAFTON

RICHFIELD, N.J.
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# LABORATORY AND FIELD EXERCISES IN PHYSICAL GEOGRAPHY

## CHAPTER I

### THE WORLD AS A GLOBE

#### EXERCISE I

#### To find a North and South Line

Place[1] a table before a window through which the sun shines at noon. Place on the table a sheet of paper and put weights on it to keep it from moving. Stand on the paper a small chalk box, or other square-cornered box, on end. At 11 : 15 mark the position of the shadow of a corner of the box. Do the same at 11 : 30 and 11 : 45, then for every five minutes till 12 : 15, and finally at 12 : 30 and 12 : 45. Draw a line connecting these points. Mark the position on the paper of the corner just below the one the position of whose shadow has been taken. Draw the shortest line possible from the lower corner of the box to this line. To do this, use as a center the dot marking the position of the corner of the box, and with a pencil and string draw an arc of a circumference which shall touch the line

[1] To the Pupil. Write in a notebook all that you do under each exercise. Write answers to the questions asked and make a record of all other observations made.

previously drawn at only one point. Connect this point with the center of the circle. This line will be a north and south line. Why? Before moving the paper find some fixed objects that have the same direction as this line, such as some edge of a building or the line connecting two posts or trees. Fold the paper and paste in your notebook.

### EXERCISE II (*see Appendix A*)

### TO FIND THE LATITUDE (*Approximately*)

*Apparatus.* Take a piece of lath about a foot long and screw it 1 inch from the end to the side of a sharpened post, which should be about 8 inches long, with the upper part square and the lower part round. Saw off the end

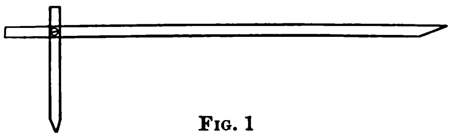


FIG. 1

of the lath at an acute angle, as shown in the figure. Provide five sharpened stakes about $\frac{3}{8}$ inch square, two of which should be a foot long, two $1\frac{1}{2}$ feet, and one 2 feet.

Drive the stake, with pointer attached, about two thirds of the way into the ground. In the early morning turn the pointer toward the sun. The correct position may be found by holding a piece of paper behind the pointer and turning the lath till its shadow is of the same size as the end of the lath itself. Drive a stake into the ground so that the tip of the pointer just touches the top of the stake at the inner corner. In the same way mark the position of the end of the pointer at each of four other observations taken, one during the middle of the forenoon, one at about

noon, one during the middle of the afternoon, and one a little while before sunset.

Procure a piece of board $2\frac{1}{2}$ feet long by $1\frac{1}{2}$ feet wide, or two narrower pieces may be fastened together by means of a cleat. Placing one edge of this on the ground, allow it to rest on the tops of the stakes so that each stake touches the board. This marks out a plane parallel to that followed by the sun during the day. The angle which this plane makes with a perpendicular is the latitude. Why? To find this angle, procure a protractor and suspend from its center a pendulum. Go 10 or 15 feet to one side and, sighting at the board with the protractor so that its edge shall be in line with the board, read the angle which the board makes with the pendulum. To determine the amount of error, compare your result with the latitude as found on a map of your state.

### EXERCISE III

#### To demonstrate the Rotation of the Earth and to find the Latitude

The requisites for this experiment are a long pendulum, consisting of an iron ball of several pounds weight suspended by as small a wire as will hold it, and a high support for the pendulum. This last condition can be found in the open space in the stairway of the school building, where the height of several stories can be utilized. Screw a hook into the ceiling just over the center of the open area, in such a position that it will be in a plane at right angles to that in which the pendulum is to vibrate, thus reducing friction. Pass the wire over the hook and fasten it, allowing the ball to swing just free from the floor. Draw a chalk line on the floor in the plane in which

the pendulum is to vibrate, allowing this line to pass through the point just beneath the center of the ball. Make a loop of a piece of string, and passing it around the greatest diameter of the ball, pull it back and fasten it to a support placed over the chalk line. See that no doors or windows are open to cause a draft. Burn off the string with a match. Record the time. Watch till the bob nearly stops swinging. What results do you observe? What is the explanation? In which direction is the bob deflected? If the pendulum were set swinging at either pole, how would the results differ? How at the equator? How at other points between?

As the time required for the meridian to rotate depends on the distance of the station from the equator, this experiment furnishes a means of finding the latitude. When the bob has nearly stopped, find the direction in which it swings. Take two pieces of string about a yard long and attach to each a small weight. At either side of the extreme of the vibration of the swinging bob suspend one of these small pendulums and arrange them so that they shall be in the same plane as that in which the bob swings. Take the time, and mark a point on the floor just beneath each of the small bobs, connecting these points by a chalk line. Measure the angle which this line makes with the line first drawn. You now have the angle of deflection and the time taken for it. Compute the angle of deflection for an hour. Divide 360° by this angle and this will give the number of hours required for a complete rotation of the meridian. Divide 24, the number of hours in a day, by the number previously obtained, and the quotient will be the sine of the latitude of your locality. From the table ascertain the angle which corresponds to this sine. This is your approximate latitude. Compare with the result of

the pievious experiment and with the latitude as found on a map of your locality.[1]

TABLE OF SINES

| Sine | Angle | Sine | Angle | Sine | Angle | Sine | Angle |
|---|---|---|---|---|---|---|---|
| .500 | 30 | .574 | 35 | .643 | 40 | .707 | 45 |
| .515 | 31 | .588 | 36 | .656 | 41 | .719 | 46 |
| .530 | 32 | .602 | 37 | .669 | 42 | .731 | 47 |
| .545 | 33 | .616 | 38 | .682 | 43 | .743 | 48 |
| .559 | 34 | .629 | 39 | .695 | 44 | .755 | 49 |

## EXERCISE IV

### Relation of the Earth to the Sun

Procure a piece of paper 20 inches square. Through the center draw a line parallel to the edge. Let each inch represent a distance of 10,000,000 miles. On each side of the middle of the line place a pin, so that they shall be $\frac{3}{10}$ inch apart. How many miles does this represent? With a piece of thread that will not stretch make a loop 19 inches around. Put one end of this loop around the pins, and with a pencil at the other end draw a curve around the pins, keeping the string taut. This curve is an ellipse and represents the form of the earth's orbit around the sun. Around one of the pins draw a circle to scale to represent the sun, whose diameter may be taken as

[1] For more detailed suggestions see Goode in the *Journal of School Geography*, October, 1899.

1,000,000 miles, although really about $\frac{1}{9}$ smaller than this. What will the diameter of this circle be? What would be the size of a circle to represent the earth, whose diameter is about 8000 miles? The points where the ellipse cuts the straight line represent the extremes of the distances of the earth from the sun. Label the point nearest the sun "perihelion," and the other point "aphelion." From the length of the lines and the scale used determine each distance. Through the focus at which the sun is situated draw a perpendicular to the line first drawn in this exercise till it intersects the orbit on either side. About $1\frac{1}{2}$ inches from each of these points, measured clockwise on the circumference, make a dot. These dots represent approximately the position of the equinoxes. Place the paper with perihelion at the right and mark the point on the upper side "vernal equinox," and the other point "autumnal equinox." Indicate the direction of the earth's motion by arrows.

## EXERCISE V

### The Seasons

1. On the point marked "perihelion" in the previous experiment place a small globe or a wooden ball supported on a wire. Move it clockwise on the circumference about $1\frac{1}{2}$ inches. Tip the axis of the globe away from the sun till it forms an angle of $23\frac{1}{2}°$ (about $\frac{1}{4}$ of a right angle) with a perpendicular to the plane of the orbit. This represents the position of the earth on December 21.

2. At the focus where the sun is located set up a pin or piece of wire of such a length that its end is opposite the center of the globe. Allow this end to represent the position of the sun.

3. Take a piece of wire a little longer than the circumference of the globe and bend it around the globe in a great circle in a plane perpendicular to a line extending to the point representing the sun. This wire marks the limits of that half of the globe which receives sunshine at any given moment. Keeping this unchanged, turn the globe on its axis to show the succession of day and night and answer the following questions.

(*a*) Is there any region that receives no sunlight during the day? How many degrees from the pole does it extend? What name is given to this zone? What conditions prevail at the other pole?

(*b*) How many degrees south of the equator is the sun seen directly overhead at this time? What name is given to the zone within these limits on either side of the equator? What are the zones between this one and those around the poles called?

(*c*) How do night and day in each zone compare in length?

(*d*) Which hemisphere receives the more sunshine, the northern or southern?

(*e*) How does the inclination of the sun's rays vary as you pass from pole to pole?

4. Place the globe on a point $1\frac{1}{2}$ inches from the aphelion, toward the vernal equinox, keeping the axis parallel to its first position. This represents the position of the earth on June 21. Answer the same questions as in the preceding case.

5. Place the globe at the equinoxes and at each one answer questions (*c*), (*d*), (*e*), and the first part of (*a*).

6. What zones always have sunlight at some time during each twenty-four hours?

7. As a result of your observations state what two factors cause the change of seasons. In what way do these

factors act so as to cause the earth to receive more heat in the summer than in the winter? When is the earth nearest the sun, in winter or summer? What effect does this have on the range of temperature during the seasons?

8. Place the globe so that its axis is perpendicular to the plane of its orbit, and determine what the effect would be on the various zones at the different seasons of the year. Place the globe so that its axis is parallel to the plane of its orbit and determine the effects.

9. Make these same observations at home in the evening, using a lamp to represent the sun.

10. What part of your exercise illustrates the cause of day and night? What is the cause?

## EXERCISE VI

### Relative Position of Sun, Earth, and Moon at the Different Phases of the Moon

1. Allowing a line 1 inch long to represent 8000 miles, what would be the diameters of circles representing the moon, earth, and sun, whose approximate diameters are respectively 2000, 8000, and 900,000 miles? On the same scale, how many feet from the circle representing the earth would those circles representing the moon and sun be placed, the distances being respectively about 250,000 and 93,000,000 miles?

2. In the following exercise no attempt is made to draw the various circles to the same scale. At the right-hand side of your notebook draw a circle 2 inches in diameter to represent the moon's orbit, which is really an ellipse. On the left-hand side of the page just opposite draw a circle $\frac{1}{4}$ inch in diameter to represent the position but not the relative size and distance of the sun.

Make a dot at the center of the first circle to represent the position but not the size of the earth. Draw four circles, each of $\frac{1}{4}$ inch diameter, using as centers the point nearest the sun, the point farthest away from the sun, and the two points halfway between these positions — points on the circumference of the right-hand circle — to represent different positions of the moon. Fill in with lead pencil that half of each circle which is away from the sun and so receives no light, leaving the other portion white to represent the illuminated portion.

3. When the moon is nearest the sun, how much of the illuminated portion can be seen from the earth? What phase of the moon is this called? When the moon is farthest from the sun, how much of the illuminated portion do we see? What phase of the moon is this? What portions do we see when the moon is halfway between these points? What phases are these?

4. At what phases of the moon are the sun, earth, and moon nearly in a straight line?

## EXERCISE VII

### Distances on the Earth drawn to Scale

1. What is the circumference of the earth expressed in the nearest thousands of miles? Allowing a line 1 inch long to represent 5000 miles, draw a straight line to represent the length of the circumference of the earth.

2. Just under it draw another to represent the diameter of the earth.

3. On a blank weather map of the United States find the distance in miles in a straight line from New York City to the following cities, using the scale of miles given on the map: San Francisco, Chicago, Washington, Boston.

Using the same scale as in 1 and 2, draw lines to represent these distances.

4. Label each line, showing the distance it represents. What proportion of the diameter of the earth is the distance from New York to San Francisco? What distance would one travel if he were to start from New York and go eastward till he reached San Francisco?

5. Using the same scale as before, draw a straight line to represent the distance around that part of the United States represented on the map.

# CHAPTER II

## THE LAND

### EXERCISE VIII (*see Appendix A*)

### Study of a Topographic Map of your Locality

1. (*a*) *Contour lines.* These are the brown lines found on all parts of the map. Before studying these, make the following preliminary study. Make a small model of a mountainous country, which, in addition to valleys, spurs, steep slopes, and peaks, should contain also a level area. This may be made by first nailing together blocks of wood cut out so as to give the general outline desired. This may then be covered with putty by means of which the finer details of relief may be molded. Pieces of iron or lead should be attached to the base of the model, sufficiently heavy to keep it from floating when submerged in water. Place the model in a water-tight receptacle a little higher than itself. A box with glass sides, similar to those used for aquaria, is most satisfactory, but in place of this a tin box made by the tinsmith may be used.

In place of the apparatus just described, the following much simpler equipment may be used. Secure an ordinary battery jar and a stone small enough to go inside and of such shape as to represent some land form. A little searching among a pile of stones will usually enable one to find some which are fair types of hills, ridges, and valleys. While the finer details cannot be shown as clearly as with a specially prepared model, yet the meaning of

contour lines can be brought out quite as well with the stones as with the special model. If the stones are used, a smaller contour interval than that suggested in (*b*) will need to be taken.

(*b*) Pour into the box or jar enough water to cover the base of the model. Having provided a sheet of paper of the same size as the base, draw a line near the edge to correspond with the water line on the model. Add sufficient water to raise the level ½ inch. Draw another line just inside the first to represent the new water line. Proceed in this way to add water ½ inch at a time till only a small peak of the model is left uncovered. After each addition of water draw a line on your paper to correspond with the coast line of the model. Take special care to see that the distance of the line from the edge of the paper shall be the same as the horizontal distance of the water line from the edge of the model.

(*c*) You have now made a contour map of the model, each line that you have drawn representing a contour line. The contour interval is ½ inch. How much is the contour interval on the topographic map of your locality? Explain what this means.

(*d*) Find on the map you have drawn the following arrangements of contours, and by comparison with the corresponding parts of the model explain what each of the following signifies: (1) close together, (2) far apart, (3) in circular rings, (4) bending in towards the center of the model, (5) bending out away from the center of the model. On the topographic map find each of these arrangements of contours.

(*e*) Mark the first line drawn on your map "sea level." Mark the elevation above this line of every fourth contour and also of the highest point. On the topographic map find the elevation of the highest spot and the lowest spot.

(*f*) From a study of the model and the map that you constructed, determine the relation between the direction of contours and the direction of the slope.

(*g*) What is the meaning of the heavy brown contour lines found on the topographic map?

(*h*) How do the elevations of contours adjacent to each side of a stream compare?

(*i*) Find the relief in the vicinity of the largest stream, that is, the difference in elevation between the stream bed and the divide.

(*j*) What three general heads will include all the features shown by the contours?

2. (*a*) By what survey and under whose direction was your map made? (*b*) What is the name of your sheet? (*c*) What is the scale — how many miles to an inch?

3. Draw in your notebook an outline map of the state in which your map is situated, and mark on it the location of your map by a small rectangle of the correct proportionate size.

4. Find the following and explain what they signify: (*a*) blue lines, (*b*) heavy black lines with cross lines, (*c*) fine black lines which are in pairs and parallel, (*d*) small black squares.

5. Name a few of the principal rivers, lakes, and towns found on your map.

6. Find the fall per mile of the largest stream. To do this, find the point where the stream enters the map and take the elevation at the first point where the stream is crossed by a contour. In a similar way find the elevation where the stream leaves the map. From the elevations of these two points and the distance between them as the stream runs, find the fall per mile. Compare the total fall of the first half of the distance with that of the second half.

7. Determine the best bicycle road between two selected places as far apart as the map will permit, and find the distance between them. Distance and grade must both be taken into consideration. Describe the country along the route chosen.

8. Imagine yourself to be standing on the summit of some hill, and determine how far you can see north, east, south, and west. Write a description of the country to be seen from this point.

### EXERCISE IX (*see Appendix A*)

### To make a Cross Section of the Contour Map used in the Preceding Exercise

In your notebook, near the bottom of the page, make a line of the same length as the one drawn by the instructor on the map, and make dots to correspond in position with the cross lines on the map. In thus copying the length of the line you are using the same horizontal scale as is found on the map. What is it? Number the dots to correspond with the cross lines. Find the elevation of cross line No. 1. Write the number of feet under the figure 1 in your notebook. In the same way write the height for each of the other cross lines. For the vertical scale take $\frac{1}{16}$ inch for every 100 feet. Measure up from your line distances to represent the elevation under each dot. For instance, if the elevation of point No. 1 is 700 feet, measure up from the line $\frac{7}{16}$ inch and make a dot at this place. Proceed in the same way with the other elevations. Draw a smooth line connecting these points.

Using the same base line as in the previous exercise, make another cross section with the same horizontal scale as above, but with the vertical scale 1 inch to 5000 feet.

This will make the horizontal and vertical scales about the same. This is the true profile. How much is the vertical exaggeration in the first section? In both of these sections mark in blue bodies of water crossed by the line. Label the profiles and write near them both the horizontal and vertical scales. Do the same with every profile made.

### EXERCISE X

### Study of a Hachure Map

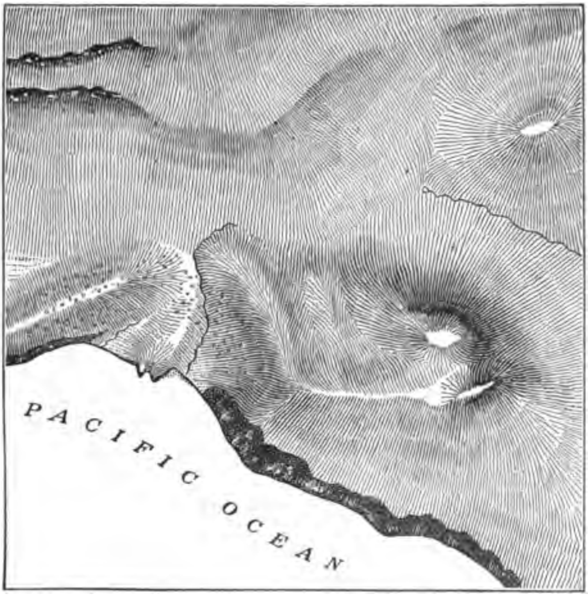



Fig. 2. Representation of Relief by Hachures

1. Find on the map each of the following features and explain what it signifies: (*a*) a white oval or circular spot with lines radiating from it in every direction, (*b*) long and

fine lines, (*c*) short and heavy lines, (*d*) black areas without distinct lines, (*e*) places where rows of lines come together, forming a letter V.

2. To make a profile of a hachure map, draw a line connecting the summits of two hills and extended so as to be about 2 inches long. In your notebook draw a line of the same length. On this make dots to indicate the location of hills and valleys. About an inch above this line make a profile, using the dots as guides in placing the hills and valleys. Be careful to have the profile slope gently where the lines are long and fine, more steeply where the lines are short and heavy, and very steeply where there are black areas without distinct lines.

### EXERCISE XI (*see Appendix A*)

### To reproduce in Hachures a Part of the Contour Map of the Wicomico Region, Maryland

1. Reproduce as much of the lower right-hand corner of the Wicomico sheet, Maryland, as is included between the edges of the map, 38° 20′ latitude and 76° 50′ longitude.

2. Draw a rectangle in your notebook of the same size as this one on the map. Draw lines to represent the streams and the eastern shore line of the Wicomico River.

3. Review your observations in the eighth exercise under 1 (*f*). Wherever there is a level area leave this without shading. In the northern part of the rectangle is a flat-topped hill bounded by the 140-foot contour line. Copy this line lightly in your notebook. Beginning with this, draw the hachures for the rest of the area, showing the direction of the slopes by the direction of the hachures, and the amount of slope by the length and shading of the hachures, none of which should cross the streams,

making long fine hachures for gentle slopes and short heavy ones for steep slopes. Do not make any of the lines longer than $\frac{3}{8}$ inch, and whenever the slope changes, show the change by a difference in the hachures. When all the area is finished, carefully erase the line drawn to represent the 140-foot contour.

In the remaining map studies the cross sections are to be constructed in the same manner as the one already made in Exercise IX, only no line is to be drawn on the maps. Instead, lay a piece of paper on the map so that its edge connects the points between which the profile is to be drawn. Make dots on the paper opposite the points whose elevations are to be taken, and under each dot put the elevation of that point. Now lay the paper on your notebook, and draw a line equal in length to the distance marked to show the limits of the profile. On this line mark the dots and elevations to correspond with those on the paper. Then proceed as in the previous case to construct the cross section. Whenever reference to lines on the maps is made in connection with these profiles, it will be understood that these indicate direction only and that no line is to be drawn. In each case mark the position of the streams by blue lines of the correct proportionate length.

The purpose of the observations called for in the following map studies is to bring out the topographic features. At the close of each exercise the pupil should try to picture in his mind the appearance of the land the map of which he has been studying.

## RIVERS

### EXERCISE XII (*see Appendix A*)

### Flood Plains

*Donaldsonville Sheet, La.*

1. Note scale and contour interval. This is the first thing to be done in the study of each of the following maps.

2. Where is the highest part of the plain? On what, then, is the river flowing?

3. What is the nature of most of the area?

4. How high above sea level is the lowest part of the region? And yet it is 150 miles from the sea as the river flows.

5. Does Bayou Conway flow toward or away from the river?

6. What determines the direction of the main roads? Where are the settlements located?

7. Make a profile along a line crossing the word "river" and extending on each side to the marsh. Horizontal scale as on the map, vertical scale 1 inch to 100 feet. Take the elevations at the ends of the line and at the contours nearest each side of the river.

### EXERCISE XIII

### River Terraces

*Springfield Sheet, Mass.*

1. Make a profile along the line of 42° 10′ latitude between longitude 70° 35′ and 70° 40′ (horizontal scale as on map, vertical scale 1 inch to 200 feet). Take the

elevations at the ends of the line, at each side of the river, at the heavy contours on the west side, and at the 200-foot and 80-foot contours on the east side.

2. As you pass from the east end of the line to the 200-foot contour, what is the nature of the land? What is it between the railroad and river? What separates these two stretches? How has the level area just east of the river been formed? Does its similarity to the area at the top of the bank suggest how the upper area may have been formed? In what ways must the conditions have differed from those found now?

### EXERCISE XIV

### Lengthwise and Crosswise Valleys

*Harper's Ferry Sheet, Va., W. Va., Md.*

1. Find the lengthwise valley west of the Blue Ridge and the crosswise valley cutting across the Ridge.

2. Describe the first valley. Describe the second valley where it cuts the Blue Ridge.

3. What is the local base level of the Shenandoah River?

4. If, on account of a difference in the hardness of the rock, the Shenandoah should do its vertical erosion more quickly than the Potomac, in what way would the first river use its extra time and energy? Do you see any evidence on the map that bears out your answer?

5. Make a profile of the crosswise valley from Maryland Heights to Londoun Heights, and one of the lengthwise valley from Londoun Heights to Leetown (horizontal scale as on map, vertical scale 1 inch to 1000 feet). In each case take the elevations at the ends of the line, at each side of the river, and at the heavy contour lines.

## EXERCISE XV

### Young Rivers

*Echo Cliffs Sheet, Ariz.*

1. Make a cross section from the letter *y* to the letter *v* in the word "Yavapai" (horizontal scale 1 inch to 2 miles, vertical scale 1 inch to 1000 feet). Take the elevations at the ends of the line and at the heavy contours.

2. Find (*a*) the fall per mile of the Colorado River, (*b*) the width of the canyon at the top; (*c*) describe the slope of the valley sides.

3. (*a*) How does the width of the valley bottom compare with the width of the stream? (*b*) Are there any flood plains?

4. What do you find about the distinctness of the divide between Navajo Creek and the Little Colorado River? Is its location ill defined or sharply defined?

## EXERCISE XVI

### Mature Rivers

*Charleston Sheet, W. Va.*

1. Make a profile from Rocky Fork to the western end of Grapevine Knob (horizontal scale as on the map, vertical scale 1 inch to 1000 feet). Take the elevations at each end of the line, at the carriage roads, and at the highest point between two adjacent roads.

2. In studying the features of mature and old rivers keep in mind the conditions found on the previous map or maps.

3. (*a*) Describe the slopes found here. (*b*) Find the fall of the Kanawha River. (*c*) How does the slope of the

smaller streams compare with this? (*d*) Does the Kanawha have a flood plain?

4. How do the slope of the banks and the width of the valley bottom compare with these features in the Colorado, as found on the preceding sheet?

5. How many lakes do you find?

6. Find the divide between the Coal and Kanawha rivers. Can its position and limits be distinctly located? How wide is it?

7. (*a*) Are the tributaries few or numerous? (*b*) Is there opportunity for them to increase their length by cutting back at their headwaters? How does this compare with the tributaries of the Colorado? (*c*) Do you find any area that is not well drained?

## EXERCISE XVII

### Old Rivers

*Caldwell Sheet, Kan.*

1. Make a cross section along the carriage road running north and south through Milan, extending five squares on either side (horizontal scale as on map, vertical scale 1 inch to 1000 feet). Take the elevations at the contours on each side of the streams and at the contours nearest the intersections of the roads.

2. (*a*) Find the fall of the Chibaskia River. (*b*) What do you note about the course of the river?

3. Describe the width, appearance, and distinctness of the divide between this river and Slate Creek.

4. How much is the difference in elevation between the lowest and highest points?

5. Describe the slopes found here.

6. In what kind of lines do the carriage roads extend? What does this indicate?

7. What do you note about the number and location of villages? Does the region seem to be favorable for settlement?

8. From a study of your notes and profiles of these three maps make a comparison of the characteristics of youth, maturity, and old age in the tabular form given below, which should be copied in your notebook.

| Age of River | Slope of Valley Sides | Velocity of Larger Streams | Character of Divides | Width of Valleys |
|---|---|---|---|---|
| Youth | | | | |
| Maturity | | | | |
| Old Age | | | | |

## EXERCISE XVIII

### Longitudinal Profiles of Rivers

#### *a. Of the Yellowstone River*

1. Four inches from the top of your notebook draw a straight line 6 inches long. This is to represent the level of the mouth of the river, from which the heights of the river are to be measured.

2. Beginning at the left of the line, measure off from the end each of the distances from the mouth given in the second column, on the scale of 1 inch to 100 miles. Make a dot on the line for each distance and number them to correspond with the numbers in the first column.

Under each of these numbers put the corresponding height above the mouth level.

3. Measure up from the line distances to correspond with the heights above the mouth on the scale of 1 inch to 2000 feet. Make a dot in each case at the proper distance. Connect these dots by a smooth line slightly concave upward.

| | Distance from Mouth | Height above Level of Mouth |
|---|---|---|
| 1 | 100 miles | 245 feet |
| 2 | 215 " | 610 " |
| 3 | 331 " | 1224 " |
| 4 | 400 " | 1992 " |
| 5 | 486 " | 3145 " |
| 6 | 533 " | 4145 " |
| 7 | 552 " | 5445 " |
| 8 | 569 " | 5886 " |

*b. Of the Ohio River*

1. One inch below the base line previously drawn, construct another line 11 inches long. Using the table, proceed as in the previous case to construct a profile of the Ohio.

| | Distance from Mouth | Height above Level of Mouth |
|---|---|---|
| 1 | 123 miles | 27 feet |
| 2 | 378 " | 120 " |
| 3 | 744 " | 270 " |
| 4 | 963 " | 428 " |
| 5 | 1048 " | 588 " |

2. (*a*) In what stage of development is each of these rivers? (*b*) What differences in form do you note between these two profiles? (*c*) In what part of the Yellowstone do you find the steepest slope? In what part the gentlest slope?

## EXERCISE XIX

### A Study of the Mississippi River

*Map of the Alluvial Valley of the Mississippi River*

1. The flood plain is tinted blue and the land above flood levels white (scale 5 miles to an inch). The figures near the river indicate distances from Cairo, Ill., as the river runs.

2. What is the form of the lower end of the delta? How many distributaries or passes are there?

3. Does Bayou La Fourche flow toward or away from the river? Do you find other distributaries?

4. What is the first distributary as you follow the river south from Vicksburg? If the point where this leaves the river be taken as the head of the delta, how far out has it been built? From measurements on the map, estimate approximately the area of the delta. What cities have been built on this delta?

5. What is the position of the river with reference to its flood plain?

6. What is the average width of the flood plain above the head of the delta?

7. (*a*) What do you note about the location of the lakes with reference to the flood plain and the land on either side? (*b*) What is the shape of the lakes near the river? (*c*) Do you find any part of the river that will be soon left as a cut-off or lake as the work of the river progresses? Make a drawing in your notebook to illustrate this feature.

8. What is characteristic of the course of the river through the whole length shown on these maps? How far is it in a straight line from the point where the river enters the map at latitude 34° 20′ to where it leaves it at latitude 33° 10′? How far does the river flow in going this distance?

## GLACIAL FORMATIONS

### EXERCISE XX

### Glacial Moraines

*Eagle Sheet, Wis.*

1. What is characteristic of the courses of the streams?

2. What else do you notice concerning the water features shown here?

3. What is the appearance of the land between the streams?

4. Are the contours sinuous or even? What is thus shown concerning the regularity of the surface?

5. How does a section across Fox River above Lake Mukwonago compare with one just below the lake?

6. How does the relief at different points on the map compare? For example, compare the relief just northeast of Eagleville with that just south.

7. (*a*) Do you find any ponds without outlet? (*b*) In the stream north of Eagleville how does the slope of the upper half compare with that of the lower half? In our study of the Yellowstone and Ohio rivers what kind of longitudinal profile did we find that a river tends to make? (*c*) What do your observations under (*a*) and (*b*) show concerning the age of the streams and land features found here? Give reasons for your answer.

8. In the *Third Annual Report of the United States Geological Survey* examine plates facing pages 318 and 370.

## EXERCISE XXI

### Drumlins

*Sun Prairie Sheet, Wis.*

1. What is the shape of the hills found here?

2. What is their average height above the surrounding country?

3. What do you notice about the direction of their longer axes? Can you explain?

4. What is the nature of the land between these hills?

5. What do you observe concerning the number of streams and their courses?

6. What is the relation of the streams to the drumlins —do they cut through or flow around them? What is thus shown concerning the relative age of the hills and streams? Were the courses of the streams carved after or before the hills were formed?

7. Are the sides of the drumlins smooth or are they dissected by streams? What do you infer concerning the time that these hills have been exposed to erosion?

8. See Fig. 103 in Gilbert and Brigham's *Introduction to Physical Geography.*

9. Does the parallelism of the longer axes of these drumlins, extending in the same general direction as that in which the glacier moved, suggest any explanation regarding the way in which these drumlins may have been formed?

10. What other maps have you studied that show the influence of the glacial period on man?

# PLAINS

## EXERCISE XXII

### Coastal Plains

*Glassboro Sheet, N. J.*

1. (*a*) What do the tufts of blue lines beside the streams signify? (*b*) Find the fall of the Maurice River.

2. What is the appearance of the interstream areas? What is their average height?

3. (*a*) Are the valleys shallow or deep? (*b*) Do the branches of the principal streams cut back so that their sources are near together and all the area is well drained, or are there level areas on which no streams are found?

4. What is the average relief along the Maurice River?

5. What is the difference in elevation between the highest point in the northern part and the highest point in the southern part of the map? About how many miles apart are they?

6. (*a*) What do you note about the location of the roads and railroads with reference to the valleys and interstream areas? (*b*) In what kind of lines do they extend? Why? Are the roads around your home similar? Why?

7. What do you note concerning the number, size, and location of the villages? Does the map suggest a reason for their location?

8. Make a profile along a line just above the village of Clayton, beginning at the letter *Y* and extending east 5 inches (horizontal scale as on the map, vertical scale 1 inch to 200 feet). Take the elevations at the ends of the line, at the contours on either side of the streams, at the letter *O*, and at the highest point between the two streams.

9. Summarize briefly in a sentence the features of the land represented on this map as regards (*a*) elevation, (*b*) slope, (*c*) relief.

## EXERCISE XXIII

### Lake Plains

#### *a. Fargo Sheet, N. Dak.*

1. What is the elevation of the region expressed in nearest hundreds of feet?

2. What is the average distance between the contour lines? What is thus shown concerning this region?

3. Where are the roads and buildings located? Judging from their number, does the region seem to be well adapted for settlement?

4. What do you observe concerning the number and courses of the streams? Describe the valleys as regards width and depth.

5. Make a profile along the line of 46° 50′ latitude, beginning with the contour at the east bank of the Sheyenne River and extending to the third contour east of the Red River (horizontal scale as on the map, vertical scale 1 inch to 200 feet). Take the elevation of each contour crossed.

6. This region was once the bed of a huge lake of glacial times, Lake Agassiz, of which Lake Winnipeg is a remnant. On account of the fertility of the soil and the level surface, this country is one of the best wheat regions in the world.

#### *b. Toele Valley Sheet, Utah*

1. The area represented on this map is a part of the Great Basin region. In what direction do the mountains extend? What is the appearance of the areas between these mountains?

2. What becomes of most of the streams that flow down from the mountains? Can you suggest an explanation?

3. The areas between the ridges were once the bottom of a great lake, Lake Bonneville, of which Great Salt Lake is a shrunken remnant.

4. For illustration of the features of this old lake, examine figures on pages 172 and 186 of the *Second Annual Report of the United States Geological Survey.* See Fig. 117 in Gilbert and Brigham's *Introduction to Physical Geography.*

## EXERCISE XXIV

### Glacial Plains (*Prairies*)

*Marion Sheet, Iowa*

1. Describe the appearance of the land north of Marion.

2. How much is the relief near East Branch Otter Creek?

3. Find the slope per mile of this stream.

4. Describe the valleys of the two branches of Otter Creek with reference to their depth and slope.

5. What do you note about the location and direction of the roads?

6. Make a profile along the heavy broken line just below the word "Linn," beginning at the 900-foot contour just southwest of the letter *L* and extending east to the 900-foot contour about halfway between the two *n*'s (horizontal scale as on map, vertical scale 1 inch to 200 feet). Take the elevation at each of the 900-foot contours, at the contours on either side of the stream, and at points about halfway between the 900-foot contours.

7. This area was smoothed over with drift dragged by a large ice sheet which passed over it a number of thousand years ago.

### EXERCISE XXV

### Worn-Down Plains

*A Large Part of the Great Plains*

1. Review your notes on "An Old River," Caldwell Sheet, Kansas.

2. See Plate VI in Davis' *Elementary Physical Geography.*

## PLATEAUS

### EXERCISE XXVI

### Young Plateaus

*Echo Cliffs Sheet, Ariz.*

1. Review your notes already made on this sheet and answer the following questions.

2. What is the appearance of the region each side of Echo Cliffs?

3. What is the height of the region?

4. Find the depth of the canyon of the Colorado River.

5. What do you find concerning the number of streams draining this area?

6. What do you notice about the number and length of the dry canyons?

7. What do you observe concerning the number of settlements and the location of the trails?

8. In the *Second Annual Report of the United States Geological Survey* see plates opposite pages 62, 110, 130, 144, 146, 148, and 162.

## EXERCISE XXVII

### Dissected Plateaus

*Charleston Sheet, W. Va.*

1. Review your notes of Exercise XVI.

2. How do the elevations of neighboring ridges compare? What is the significance of this?

3. What is the difference in elevation between the lowest and highest points?

4. What do you notice concerning the location of the roads and the number, size, and location of the villages?

5. See Fig. 79 in Davis' *Elementary Physical Geography.*

## EXERCISE XXVIII

### Old Plateaus

*Abilene Sheet, Tex.*

1. Describe the slope and appearance of the land in the northern third of the sheet. How high is this area?

2. What additional feature do you find in the central third?

3. These are called *mesas.* Are they obstacles to travel or are there gaps between them?

4. Taking the mesa west of Cedar Gap as a type, describe its top and sides. How high above the surrounding land is it? How do other mesas compare with this as regards elevation? How would you explain these features?

5. Beginning with the letter *G* in Cedar Gap, draw a profile along a line extending 2 inches west (horizontal scale as on map, vertical scale 1 inch to 500 feet). Take the elevations at the ends of the line, at the 2000-foot and 2100-foot contours, and at each edge of the top of the mesa.

6. See Fig. 80 in Davis' *Elementary Physical Geography.*

## MOUNTAINS

### EXERCISE XXIX

### Dissected Block Mountains

*Alturas Sheet, Cal.*

1. In what direction do the Warner Mountains extend? How many miles long are they? How many wide?

2. What is the nature of the land on either side of these mountains?

3. How high above the surrounding country do they rise?

4. What do you observe concerning the number of streams on their sides?

5. Compare the slope on the eastern with that on the western side at five or six places between Fandango and Eagle peaks. To do this compare the distances from the summit to the 5000-foot contour on each side.

6. The contours bend toward the center of the mountain where crossed by streams, and away from the center between the streams. What does this signify?

7. Are the crests of the mountains smooth and even or notched and uneven?

8. Make a profile through Cedar Peak along a line extending 3 inches east and $3\frac{1}{2}$ inches west (horizontal scale as on map, vertical scale 1 inch to 4000 feet). Take the elevations at the summit and at each of the heavy contours.

9. See Fig. 128 in Gilbert and Brigham's *Introduction to Physical Geography*.

### EXERCISE XXX

### Domed Mountains

*Henry Mountains Sheet, Utah*

1. What is the diameter of Mount Ellsworth? How high above the surrounding country does it rise?

2. (*a*) What is the direction of the contours with reference to the summit? (*b*) Do the summits of this mountain and the others north of it end in sharp peaks? (*c*) In the case of Mount Ellsworth is the steepest slope at the summit or a little way below? (*d*) Bearing in mind the observations made, describe the form of Mount Ellsworth.

3. Make a profile along a line running northwest and southeast through the summit, extending to the 5000-foot contour on each side (horizontal scale 1 inch to 2 miles, vertical scale 1 inch to 4000 feet). Take the elevations at the ends of the line, at the summit, and at each of the heavy contours.

4. In Gilbert's *Report on the Geology of the Henry Mountains* examine the frontispiece, the figures on pages 19, 23, and 27, and Plates I, II, and III at the end of the book.

### EXERCISE XXXI

### Massive Mountains

*a. The Rocky Mountains in Colorado. Canyon City Sheet, Col.*

1. In what direction do the Wet Mountains extend?

2. What is the relation to these mountains of the valley of the Arkansas River? How does its valley on the eastern part of the map differ from that on the western?

3. What effects have the smaller streams had on the slopes of the mountains?

4. Find Webster Park, just southwest of Royal Gorge. How does this differ from the country south of it?

*Huerfano Park Sheet, Col.*

1. What is the height of Blanca Peak?
2. Find Veta Pass on the southeastern part of the map. What is its relation to the streams near?
3. See Plates I and VII in Davis' *Elementary Physical Geography*. In Gilbert and Brigham's *Introduction to Physical Geography* examine Figs. 121, 123, and 124. In Fig. 123 locate the area you have been studying.

*b. The Rocky Mountains in Montana. Livingstone Sheet, Mont.*

1. Compare the summits of the Bridger and Absaroka ranges.
2. In what respects does the valley of the Yellowstone River between Lower and Yankee Jim canyons differ from that farther south? This valley was probably at one time filled by a lake.

### EXERCISE XXXII

### Worn-Down Mountains which have again been Uplifted

*Chesterfield Sheet, Mass.*

1. If you were standing on the elevation ½ mile southeast of Ringville, what would be the appearance of the sky line as you looked around in a circle? Are the hills of so nearly the same height as to form an even sky line, or is the difference between their elevations such as to give a rugged appearance?
2. With the summit of this hill as a center, draw a circle with a radius of 1½ inches. This is to represent the

sky line for one standing at the center. Make a small cross on the summits of about seven of the principal hills that come nearest the circumference, so chosen as to be scattered as much as possible. Procure a piece of unruled paper 2 inches wide and of the same length as the circumference of the circle. Bend the paper till the ends meet. Stand this on the map, making it coincide with the circumference. On the outside of the paper at the bottom make dots opposite the marked hills. Put over each dot the height of that hill. Now measure up from each of these dots distances to correspond with the elevations on the scale of 1 inch to 1000 feet. Calculate and measure the distances to the nearest thirty-second of an inch. Mark the limit of each of these distances with a dot. Connect these with a smooth line. With scissors or knife cut the paper along this line, and bend till the ends meet. This represents the sky line as it would be seen from the center of the circle. Now look again at question 1 and see whether your answer agrees with the profile. Paste this in your notebook.

3. If the valleys were filled up to the level of these hills, what would be the appearance of the region?

4. At one time there existed in New England a mountain system which was worn down to a plain, of which these hilltops are the remnant. The land was then uplifted and the processes of erosion began their work. What evidences of uplift and erosion do you find?

5. Describe the valleys with reference to their width, depth, and slope of banks. In what stage of development are the streams?

6. In the *National Geographic Monograph*, No. 9, "The Physical Geography of Southern New England," examine figures on pages 270, 272, 286, and 287.

## EXERCISE XXXIII

### Appalachian Ridges

*Harrisburg Sheet, Pa.*

1. (*a*) Describe the summits of Peters, Second, and Blue mountains. (*b*) What relation in direction do these ridges bear to each other? (*c*) How do their heights compare? (*d*) Describe their slopes.

2. What is the average depth of the valleys between these ridges? How far apart are the ridges?

3. What is the relation of streams like Clark and Stony creeks to the ridges? What is the relation of the Susquehanna River to the ridges?

4. At what points is the Susquehanna narrowest? How may this be explained? Would the same explanation apply to the presence of the ridges and valleys?

5. What do your observations made under 1 (*c*) suggest concerning the former condition of the country?

6. Where are the settlements located?

7. Make a profile from the letter *B* in Blue Mountain to the letter *d* in Third Mountain (horizontal scale as on the map, vertical scale 1 inch to 1000 feet). Take the elevations at the summits of the ridges, at the streams, at the 500-foot and 600-foot contours in the valley of Fishing Creek, and at the 400-foot and 500-foot contours in the valley of Stony Creek.

8. In the *National Geographic Monograph*, No. 6, "The Northern Appalachians," examine figures on pages 170 and 183.

## VOLCANOES

### EXERCISE XXXIV

### Young Volcanic Mountains

*Shasta Special Map, Cal.*

1. How high is Mount Shasta above the sea level? How high above the surrounding country? What is its general form?

2. As you pass from base to summit, where are the slopes steepest?

3. What evidences do you find of the beginnings of erosion?

4. What do the white patches with blue lines found near the summit represent? How many are there? How large is the largest? What formation is found at their lower ends? What have their source just below these? Why?

5. What is indicated by the brown lines in the center of Hotlum Glacier?

6. How many minor summits do you find?

*Shasta Sheet, Cal.*

7. Make a profile along a line through the top of Mount Shasta, extending northwest and southeast to the 5000-foot contour on each side (horizontal scale as on map, vertical scale 1 inch to 4000 feet). Take the elevations at the ends of the line, for every two thousand feet, and at the summit. For the profiles of this and the next two exercises use a piece of unruled paper 10 by 6 inches. Draw the base line for the Shasta profile 4 inches from the top of the paper, parallel with the shorter dimension.

8. In the *National Geographic Monograph*, No. 8, "Mount Shasta," examine figures on pages 243, 244, 258, and 260.

## EXERCISE XXXV

### Maturely Dissected Volcanic Mountains

*Mount Taylor Sheet, N.Mex.*

1. How does Mount Taylor compare with Mount Shasta as regards (*a*) elevation above surrounding country? (*b*) steepness of slopes? (*c*) regularity of form? (*d*) diameter at base?

2. Make a profile along a line through the summit, extending northwest and southeast to the 8000-foot contour on each side (scales as in the previous exercise). Take the elevations at the summits and at the heavy contours. Draw the base line 3 inches below the Shasta line.

## EXERCISE XXXVI

### Old Volcanic Mountains. Volcanic Necks

*Mount Taylor Sheet, N.Mex.*

1. Describe Cabezon Peak as regards (*a*) height above surrounding country; (*b*) slope; (*c*) form; (*d*) diameter at base.

2. Make a profile along a line from the summit, extending eastward just over the top of the letter *C* to the 6000-foot contour, and westward to the 6000-foot contour (scales as in the two preceding exercises). Take the elevations at the ends of the line, at the summit, and at the 6400-foot and 7000-foot contours. Draw this line ½ inch from the bottom of the paper.

3. Make a written comparison of these three profiles and paste the paper in your notebook.

4. See Figs. 8 and 9 in *Physiographic Types*, Folio II.

## EXERCISE XXXVII

### Lava Plateaus

*Modoc Lava Beds Sheet, Cal.*

1. What two very different kinds of land forms do you find represented on this map?

2. How wide are the lava beds? What is their average elevation?

3. What do you notice concerning the course of the Pit River?

4. These valleys were filled with liquid lava, which spread out evenly and cooled in the position in which it is now found. Do you find any evidence of the effect on the streams that might result from the blocking of the valleys by such an outpouring?

## EXERCISE XXXVIII

### A Crater containing a Lake

*Crater Lake Special Map, Ore.*

1. If one were standing on the summit of the Watchman and looking east, what would be the appearance of the land surrounding the lake? How many feet below the Watchman is the surface of the lake? How would the slope to the west compare with that to the east?

2. How wide is the lake? How deep? Has it any outlet?

3. How high above the surrounding country is the ridge around the lake?

4. Examine the streams and valleys on the southern slope to ascertain what relation they bear to the ridge surrounding the lake. Do you think that the streams in their present condition could have brought about this relation?

5. The feature referred to in 4 indicates that the mountain was once much higher than now, and that its upper part has disappeared, probably sunk, cutting off these canyons part way down the slope.

Compare this map with the Shasta Special. If you suppose that part of the map covered by the lake to be filled in with contours coming to a point, as in Shasta, with increasing slope, you will have restored in a general way the former volcano, which was probably of about the same size as Shasta.

7. Copy in your notebook the section at the bottom of the map, but making it only half as large.

8. In the *Annual Report of the Smithsonian Institution* for 1897, study the plates between pages 379 and 381. In *Physiographic Types*, Folio II, see Figs. 10 and 11. In Gilbert and Brigham's *Introduction to Physical Geography*, see Figs. 152 and 153.

## EXERCISE XXXIX

### Identification of Land Forms

Determine what type of land form is represented on the maps furnished you. In studying the map note (*a*) scale and contour interval, (*b*) elevation, (*c*) relief. First determine the general character of the country, whether that of a plain, plateau, mountain, or some other form. Then, by a more careful study, ascertain in what stage of development the land form is. If a plateau, is it young, dissected, or old? If a mountain, is it sharply dissected with steep slopes, or is it subdued with gentle slopes? If there is a river on the map, is it young, mature, or old? Is a flood plain present?

### EXERCISE XL

### Study of Minerals

To the Teacher. Before beginning the study of individual minerals each of the features suggested in the accompanying outline should be studied by means of the specimens, the pupils first noting the differences and then being told the names applied to the various characteristics. After the terms to be used are understood, each mineral may be studied as suggested below.

To the Pupil. Describe each of the minerals furnished you in accordance with the following outline, writing the description in your notebook.

1. *Form.*

   Crystalline or amorphous.

2. *Structure.*

   Granular, compact, foliated, banded, fibrous.

3. *Cleavage.*

   Perfect or imperfect. Cubic, rhombohedral, basal.

4. *Hardness.*

   Refer to scale.

5. *Specific gravity.*

   Determine by dividing weight in air by loss of weight in water.

6. *Luster.*

   Metallic, vitreous, resinous, pearly, silky.

7. *Transparency.*

   Transparent, translucent, opaque.

8. *Streak*

9. *Color.*

## EXERCISE XLI

### Study of Rocks

Describe each of the rocks in accordance with the following outline.

1. Stratified or unstratified.
2. Crystalline or amorphous.
3. Of what minerals composed.
   (*a*) relative amount of each; (*b*) color of each; (*c*) size and form of grains; (*d*) how held together.
4. Prevailing color or colors of rock. To what due.
5. After all the specimens have been studied, tell how you can distinguish between igneous, metamorphic, and sedimentary rocks, from the features suggested in 1 and 2.
6. Identify the unlabeled specimens of rocks and minerals furnished you. When you have named a specimen, compare with your written description of that mineral or rock to ascertain if your identification is correct.

## FIELD WORK (*see Appendix A*)

## EXERCISE XLII

### Weathering

1. Examine buildings, monuments, quarries, ledges, stone walls, and bowlders for evidence of weathering.

2. How does the weathered surface in each differ from a freshly exposed surface?

3. What agents may have been at work to bring about these changes?

4. Do you notice any difference in the rapidity with which the different kinds of rocks weather? Does weathering take place evenly in all parts of the exposed surface

of the same rock? Look around your locality to see if you can find results of this differential weathering on a larger scale. Refer to your text-book and find examples, in other parts of the world, of different shapes of the earth's surface due to the wasting away of the land, such as the Catskill Mountains, the ridges of Pennsylvania, and others.

5. What becomes of the weathered material? Is this motion of the land waste continuous? What are some of the forms that this waste assumes on its journey? Of what use is it to mankind meanwhile? What will the final result be if this wasting away continues for long ages? What forces may interfere with this result?

6. In order to obtain some idea of the rapidity with which weathering agents work, ascertain if you can, by inquiry, how long the surfaces you are examining have been exposed.

7. In a railroad cut or in a quarry compare the color of the material at the top with that of the material at the bottom.

8. Look to see if you can find any place where the roots of trees are aiding in breaking up the rocks. Describe what you find.

9. Name the agents of weathering, evidence of whose action you have actually seen in the field, giving examples of each.

### EXERCISE XLIII

### Stream Action

1. Study the current of a small stream. On which side of a curve is the stronger current? Make a diagram in your notebook to show this.

2. What is the action of the stream on the bank nearest the current? What is taking place on the opposite bank,

where the current is weaker? Compare the slope of the two banks.

3. Examine other parts of the stream to see if you can find more advanced stages of this process. In this connection study a topographic map of the lower Mississippi River, or refer to illustrations and discussion in the text-book.

4. This action is known as *lateral erosion.* Do you find any evidences of vertical erosion anywhere in the stream? How does the velocity of the stream where vertical erosion is most prominent compare with that where lateral erosion is taking place? Explain then the conditions, as regards swiftness of current, under which each kind of erosion occurs. For an example of vertical erosion look up a discussion of the Colorado River.

5. Where lateral erosion is taking place, does the stream tend to be crooked or straight? What is the appearance of the land on either side of the stream where lateral erosion is occurring? What is the width of the flood plain? Of what kind of material is it composed? Describe the material as regards shape and arrangement. For examples of flood plains look up the Mississippi, Rhine, and Nile rivers.

6. Do you find in the stream alternations of rapids with reaches of quiet water? In the reaches what determines the depth to which the channel is cut? This is known as a local base level. What is the final base level of a stream? What do you note concerning the strength of current in these reaches? These are said to be graded, that is, there is just sufficient slope to allow the current to wash along the waste furnished. When may the whole stream be said to be graded?

7. Do you find the stream actually carrying any sediment? (Observe just after a rain.) At other times do you find any motion of the sediment along the bottom of the stream? What effect will the motion of these particles have on the bed of the stream? Do you find any large pebbles in the stream which the current cannot move? How do you account for their presence here? What is the source of the material which the stream is carrying and depositing? Note the amount of erosion that the stream you are studying has accomplished. Read about the amount done by any large river system. Which indicates the larger amount of weathering and erosion, a river with a steep narrow gorge like that of the Colorado, or a broad open valley like that of the Mississippi?

8. In broadening valleys what part do weathering and erosion play respectively? If these processes continue for long periods, without the intervention of other forces, what will be the final form of the surrounding country? In what stage of this cycle should you judge the stream you are studying to be, — that is, does it seem to have nearly reached this final stage, to be fairly on the way towards it, or to be only just beginning? Look up examples of each of these stages in other parts of the world.

9. After a heavy rain examine the gullies by the roadside for examples of erosion and deposition. Describe what you find. Make a map of the area.

10. Write a brief account of what you have learned regarding stream action.

## EXERCISE XLIV

### Drift

1. Examine both stratified and unstratified deposits. Which are the more common? What is the general form of the surface in each case?

2. In the unstratified deposit describe the material found as regards shape, relative size, and arrangement. Could this formation have been made by water? Give reasons for your answer.

3. Do you find any rock fragments unlike the rock of the neighboring ledges? Are the fragments all of one kind or quite varied in composition?

4. How do the shape and arrangement compare with those of the materials found in the flood plain? How do you explain the difference?

5. Can you find any fragments that are scratched? Ascertain the significance of this. Can you find any of the underlying rock that is scratched and rounded? In what direction do these scratches extend? Do they all extend in the same direction? Is the rock deeply weathered? What inference do you draw regarding the time that has elapsed since these rocks were scoured by the glacier?

6. In the stratified deposit note the general form of the surface and the shape and arrangement of the fragments composing the deposit. How do you explain the difference between these and the unstratified deposits?

7. Do you find stratified and unstratified material in the same bed?

8. How many different surface forms of glacial deposits can you find? Visit any drumlins (see topographic map, Sun Prairie, Wis.), eskers, or kames that may be found in

your neighborhood, noting their form and size and the nature of the material composing them.

9. How does the thickness of the drift at different places compare?

10. Are the streams of the surrounding country generally smooth flowing, or are rapids common? Are ponds found in the neighborhood? Of what stage of development are these features evidence?

11. Look for drift bowlders. Note their size and abundance. Are they like the rocks of the immediate vicinity?

12. If near the southern limit of the glacial belt, visit the terminal moraine. Note its general form and size, the direction in which it extends (What relation does this bear to the direction of ice movement?), depth of deposit, and arrangement, composition, and shape of the fragments composing the moraine (see topographic map, Charlestown, R.I.).

## Additional Field Work

The field work here suggested is such as may best be done in the fall to serve as a foundation for later work. The study of weathering and stream action may be carried on in almost every locality, and the study of drift in the northeastern part of the country. The nature of further field work must depend upon the locality. An attempt may be made to explain and classify the general topographic features of the vicinity, and in some cases it may be profitable to make a topographic map of a small area.

If one is situated in a glaciated region, a trip may be made to a glacial deposit for the purpose of ascertaining how many kinds of rocks may be found. If the instructor can learn the location of the nearest outcrop northward

of each kind of rock, this will tend to give more definite impressions regarding the work of the glacier.

If one is near the sea or a large lake, observations may be made on the work of the waves in wearing back the coast and of the currents in washing away the loose material and in forming beaches and bars.

The folios of the *United States Geologic Atlas* contain very detailed information regarding the geologic and geographic features of the region treated, and from them a large number of field trips may be planned. One may ascertain whether the folio for any specified region has been published by addressing the Director of United States Geological Survey, Washington, D.C. The price of each folio is 50 cents.

# CHAPTER III

## THE ATMOSPHERE (*see Appendix A*)

### EXERCISE XLV

### Weather Observations

Copy the table given below in your notebook, extending the columns to the bottom of the page. Between eight and nine o'clock each morning make the observations called for and put the record in your notebook.

| Date | Hour | Pressure | | Temperature | | | | Clouds (amount in tenths) | Precipitation | | Winds | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | First Reading | Corrected Reading | Dry Bulb | Maximum | Minimum | Mean | | Kind | Amount | Direction | Force |
| | | | | | | | | | | | | |

The record of the force of the wind may be kept in accordance with the following scale proposed by Professor M. A. Hazen of the United States Weather Bureau.

0, calm; 1, light, just moving the leaves of trees; 2, moderate, moving branches; 3, brisk, swaying branches, blowing up dust; 4, high,

**blowing up twigs from the ground, swaying whole trees; 5, gale, breaking small branches, blowing loose bricks from chimneys; 6, hurricane or tornado, destroying everything in its path.**

When the above observations have been taken for a month, the following exercise is to be worked out.

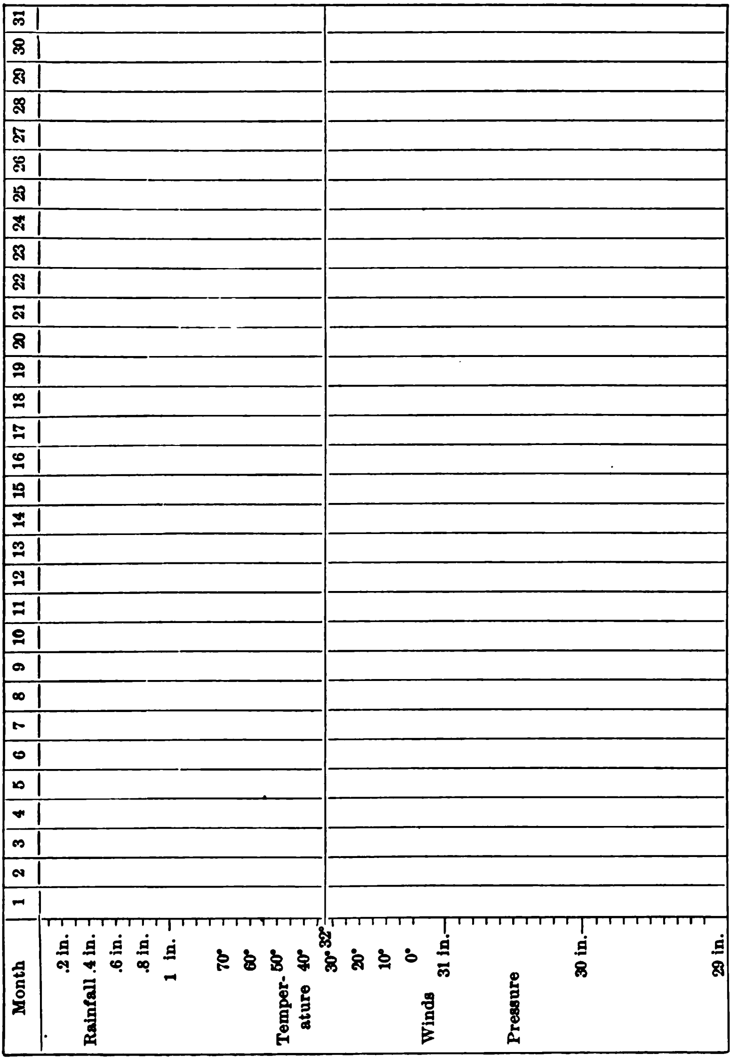
Copy on a piece of unruled paper the table given on page 51, using care to keep the dimensions the same as those found in the table. The distances on the lower part of the line at the left are made to correspond with the scale on a barometer. The line a little above this, extending across the page, represents the freezing point, and distances are measured above and below this line to correspond with the scale on a thermometer. Above this, fractions of an inch are measured off to represent the amount of rainfall.

On the table on page 51 are to be plotted the various weather conditions for the month, for which you will need three colored pencils, — red, blue, and yellow.

*Rainfall.* By means of the scale at the left measure down for each day from the top line a distance corresponding with the amount of rainfall for that day. (Remember that you will get the amount for any given day from the records of the next day.) Fill in with black the part of the columns included within these distances.

*Cloudiness.* Measure down from the same line distances to represent the cloudiness, allowing the distance to the freezing-point line to represent a cloudiness of $\frac{10}{10}$. Thus, if the amount of cloudiness were $\frac{6}{10}$, you would measure down $\frac{6}{10}$ of the distance to this line. Mark off the proportionate distance for each day and fill in down to these points with yellow.

*Temperature.* Put a dot in each column opposite the reading on the left-hand line that corresponds with the


Month
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
Rainfall
.2 in.
.4 in.
.6 in.
.8 in.
1 in.
Temper-
ature
70°
60°
50°
40°
30°
32°
20°
10°
0°
Winds
31 in.
Pressure
30 in.
29 in.

mean temperature of that day. Connect these dots with a smooth line, using the red pencil.

*Pressure.* In a similar way, using the corrected pressure, put dots opposite that part of the scale which corresponds with the pressure for that day. Connect these dots with a blue line.

*Winds.* In the space just above the pressure line draw arrows to represent the direction of the wind for each day, having the arrows fly with the wind.

What relation do you trace between the temperature and pressure curves?

### EXERCISE XLVI

### To find the Height of a Hill by Means of a Barometer

Take the reading of the barometer at the top of the hill. By means of a thermometer find the temperature. Take the readings of the barometer and thermometer at the bottom of the hill. How do these readings compare with those taken at the top of the hill? How do you explain the difference? The approximate height of the hill in feet may be found by multiplying by 90 the difference, expressed in tenths of an inch, between the readings of the barometer.

To make allowance for any difference in temperatures, each barometric reading may first be reduced to the corresponding reading at 0° C. by using the following formula: $B = \frac{b(1-t)}{6500}$, in which $t$ stands for the temperature Centigrade, $b$ the first reading of the barometer, and $B$ the corrected reading. The Fahrenheit may be changed to the Centigrade by using the formula $C = \frac{5}{9(F-32)}$.

## EXERCISE XLVII

### To find the Dew Point

*Apparatus:* A tin cup, thermometer, and ice.

Fill the calorimeter about one fourth full of water. Add a few pieces of ice and stir carefully with the thermometer, watching the outside of the vessel. As soon as a mist begins to form, take the reading of the thermometer. This will probably be too low. To correct this add water at the temperature of the room till the mist begins to disappear, and then again take the reading of the thermometer. Take the mean of the two readings for the dew point. If the difference between the two is more than two degrees, repeat the experiment. While watching the outside of the vessel be careful not to breathe upon it.

## EXERCISE XLVIII

### Annual Distribution of Rainfall

*a. Over the whole globe*

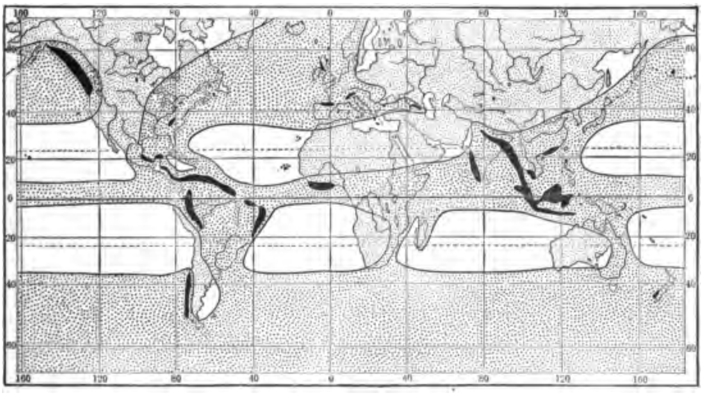


Fig. 3. Chart of Annual Rainfall

**Dark shading, heavy rainfall (over 100 inches); medium shading, moderate rainfall; light shading and blank, light rainfall (generally under 20 inches)**

1. Where do the regions of greatest rainfall occur? With what belt of winds are they associated? Where are the regions of least rainfall? What is the amount?

2. As you pass from the equatorial to the polar regions, what change in the amount of rainfall occurs?

3. How does the amount of rainfall on the coasts compare with that in the interior of the continents?

4. How does the amount of rainfall on the eastern coasts compare with that on the western in the trade-wind belt?

5. What relation do you find between mountain ranges and the amount of rainfall?

*b. In the United States*

FIG. 4. ANNUAL RAINFALL OF THE UNITED STATES

**Darkest shade, over 80 inches; lighter vertical lines, from 40 inches to 80 inches; horizontal lines, from 20 inches to 40 inches; blank, from 10 inches to 20 inches; dotted, less than 10 inches**

1. Where does the greatest amount of rainfall occur? Where the least? How much is it in each case? How much is the amount for your own state?

2. How do the interior regions compare with the coast regions?

3. Describe the distribution in each of the following regions, giving, as far as you can, explanations for the variable amounts: (*a*) Pacific coast, (*b*) the Great Basin, (*c*) Rocky Mountains, (*d*) Great Plains, (*e*) northern and central Mississippi valley, (*f*) Gulf coast, (*g*) Atlantic coast. In the first two regions what is the relation of the places of abundant and scanty rainfall to the Sierra Nevada and Coast ranges.

### EXERCISE XLIX

### The Effects of Lands and Oceans on Temperature

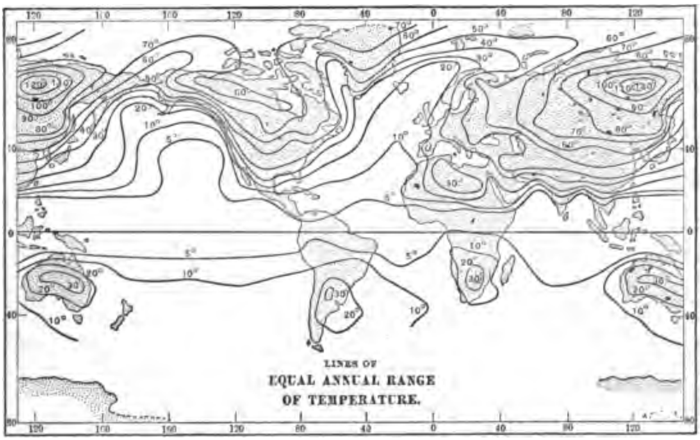



Fig. 5. Chart of Annual Range of Temperature

1. Turn to Figs. 6 and 7. For the winter do the isotherms over the lands in the northern hemisphere bend toward or away from the equator? Which way do they bend over the oceans? In the summer how do the isotherms bend over the lands and oceans?

2. In winter how do the temperatures over the land compare with those over the ocean in the same latitude? How do they compare in summer?

3. Fig. 5 shows the annual range of temperature, — that is, the difference between the summer and winter temperatures.

4. How much is the greatest range? Where is it found?

5. Compare the range over the lands with that over the oceans along the latitude circle of 40° north latitude. Compare the range over the interior of the continents with that over the coast. Compare the range over the eastern and western coasts of the northern hemisphere in temperate latitudes.

6. State your conclusions concerning the effects of lands and oceans on the changes of temperature during the year.

## EXERCISE L

### The Heat Equator and Cold Pole

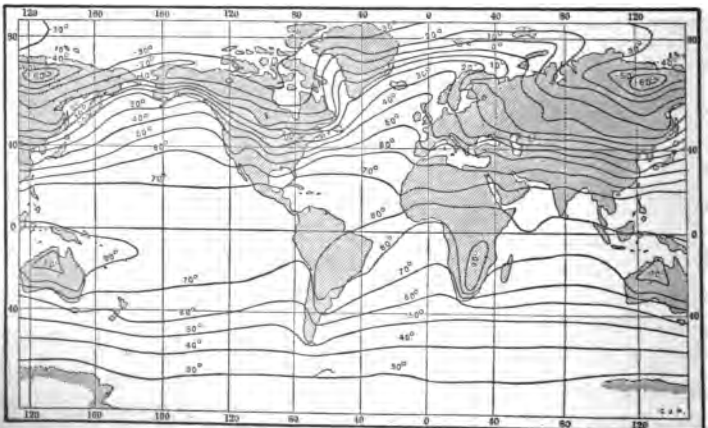


Fig. 6. Isotherms for January

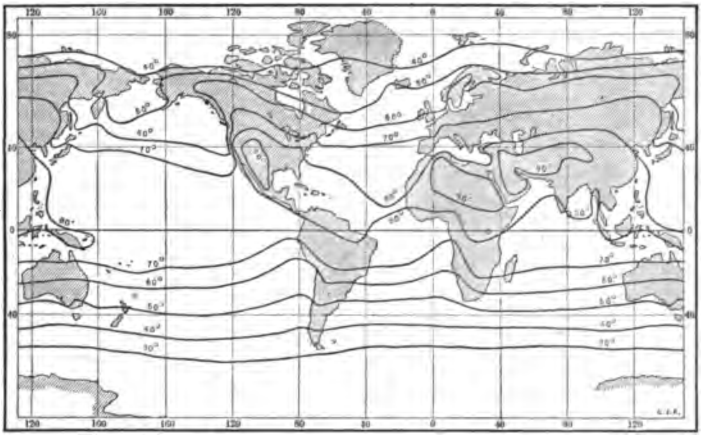


FIG. 7. ISOTHERMS FOR JULY

1. In Figs. 6 and 7 draw the heat equator, which is a line running through places of the highest temperature.

2. In which month does the heat equator stand farther from the geographic equator? Which hemisphere is having its summer at this time?

3. Where does the heat equator bend farther from the geographic equator, on the oceans or on the lands? Through how many degrees does the heat equator migrate in its greatest range?

4. On which side of the geographic equator is the heat equator situated for the larger part of the year? On which side of the equator is the larger amount of land found? What is thus suggested as the cause for the situation of the heat equator in one hemisphere for more than half of the year?

5. In your notebook draw a straight line to represent the geographic equator, as in the figures. Make a rough sketch to show the outlines of the lands 40° north and

south of the equator. Draw a line to represent the neat equator for January. On the same map draw another line to represent the heat equator for July. Label each line.

6. Is the location of the cold pole, that is, the coldest spot, for January at the pole? If not, where is it? What is the temperature found to be at this spot? In one of the previous exercises what else was learned about this region?

### EXERCISE LI

### A Comparison of Temperatures for January and July at 40° North and South Latitude

1. In Figs. 6 and 7 compare the temperature for January in North America at 40° latitude with that in South America at 40° latitude for the same month. Do the same for July.

2. How much difference is there between the January and July temperatures in South America at latitude 40°? Compare with this the difference in North America at latitude 40°.

3. In which hemisphere are the isotherms more nearly straight? In order to explain this, make the following observations. Follow the latitude circle of 40° north across the map. What proportion of the way does it lie on the continents, as measured by the degrees of longitude? Do the same for 40° south. Compare results. Can you explain now why the isotherms are more nearly straight in the southern hemisphere?

## EXERCISE LII

### Effect of Seasons on Winds

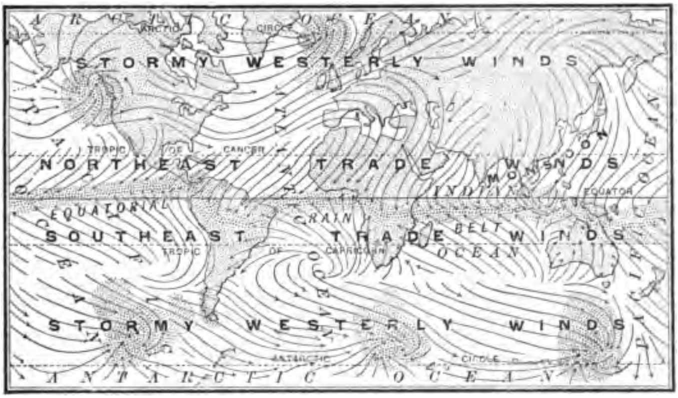



Fig. 8. Winds of January

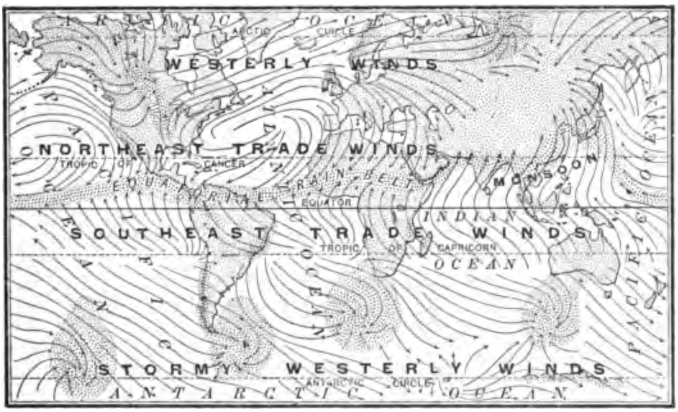



Fig. 9. Winds of July

1. Turn to Figs. 6 and 7. In which month in the northern hemisphere do you find the greater difference in

temperature between the equatorial and polar regions? What is the difference in each case?

2. What difference would this make between the strength of the winter and summer winds?

3. In the southern hemisphere are the changes in temperature from winter to summer more or less marked? Explain why.

4. Turn to Figs. 8 and 9. What belt of winds is found over Venezuela in January? What kind of weather accompanies these winds? (See text-book.) Answer the same questions for July. From a study of the map determine what other countries have similar changes.

5. In what belt of winds is southern California situated in January? What kind of weather accompanies these winds? (See text-book.) Answer the same questions for July. Ascertain what other countries have similar changes.

6. How does the direction of the trade winds on the southern coast of Asia in January compare with that in July? These winds are called *monsoons*.

## EXERCISE LIII

### Study of a Weather Map

1. (*a*) By what government department and bureau, (*b*) in what city, (*c*) on what day was your map made? At what time of day were the observations taken?

2. Find the following and explain what each signifies: (*a*) the continuous black lines, (*b*) the dotted black lines, (*c*) the circles, (*d*) the arrows attached to the circles.

3. What do the shaded areas show?

4. With what lines are the words "high" and "low" associated? What do they mean? In what direction with

reference to the two areas are the winds between them blowing?

5. What facts are given in the columns in the lower right-hand corner that are not given on the map? What do the minus and plus signs in the second column signify? What is the meaning of the abbreviations Lt. and T. in the fourth and sixth columns?

6. Are any of the facts given on the map given also in the columns?

7. What use is made of the space at the left of the columns?

8. On the map find the place that had (*a*) the highest temperature, (*b*) the lowest temperature, (*c*) the greatest air pressure, (*d*) the least air pressure. In the columns find the place that had (*a*) the highest maximum temperature, (*b*) the lowest minimum temperature, (*c*) the greatest change in twenty-four hours, (*d*) the highest wind velocity, (*e*) the greatest rainfall. In each case give the exact figures and the name of the place.

9. State all the meteorological conditions shown on the whole sheet at Washington. Do the same for your own city or for the nearest weather bureau station.

## EXERCISE LIV

### Comparison of the Conditions that exist in Cyclones (Areas of Low Pressure) and Anticyclones (Areas of High Pressure)

#### *a. Direction of winds*

1. *In Cyclones.* Secure five pieces of paper about 4 inches square, sufficiently transparent to be used for tracing paper. Through the center of each draw a straight line parallel to the edge of the paper, and mark the ends

N. and S. Make a short cross in the middle of each line. Taking one of these pieces, place it over a low area so that the long line points north and the cross line is just over the center of the area, which will be near the word "low." Copy the arrows (without the circles) within a radius of $1\frac{1}{2}$ inches. Do the same for five other low areas, using the same piece of tracing paper and placing the cross line over the center of each area. From a careful study of the arrows on the paper determine the direction of the winds in a cyclone.

2. *In anticyclones.* Starting with a new piece of paper, do the same as directed above for six high areas. What do you find about the direction of the winds in an anticyclone?

### *b. Distribution of Cloudiness and Rainfall*

1. *In cyclones.* Using the tracing paper as directed above, copy the circles, showing the state of weather for five or six cyclones.

2. *In anticyclones.* Do the same for five or six anticyclones. How do these two kinds of areas compare as regards the state of weather?

### *c. Temperature*

Using the paper as above, copy the temperatures of all stations within a radius of $1\frac{1}{2}$ inches for the eastern halves of five low areas. Do the same for the western halves of the same areas, using the same piece of paper. Find the average of the temperatures each side of the north and south line and compare them. What is the direction of the isotherms through a low area?

Label all the pieces of paper and paste them in your notebook, writing there a brief explanation of how they were obtained.

Copy in your notebook the table given below, and state briefly the conditions that have been found to exist in the two kinds of areas.

| | Cyclone | Anticyclone |
|---|---|---|
| Pressure | | |
| Direction of Winds | | |
| State of Weather | | |

### EXERCISE LV

### TO FIND THE AVERAGE RATE AND DIRECTION OF MOTION OF CYCLONES

1. For this exercise you will need a blank weather map, form *DD*, and several series of weather maps for consecutive days.

2. First study the weather maps to ascertain the general direction in which the cyclones move, so that, having found a low area for any given day, you will know on what part of the map to look for the same area the next day.

3. On the blank map place a dot to mark the position of the cyclone for the first day of the series. Mark the position of the same area for the second day with another dot. Continue to do this for each day until the area leaves the map or all the maps in a series have been used. Connect these dots by a line. Number this line 1 and mark on it an arrowhead to indicate the direction in which the area moved. By means of the scale at the bottom of the map find the average velocity of this area for twenty-four hours. In the space on the lower half of the sheet record this velocity and the direction of motion. Use the

same method of procedure for nine or ten other low areas, numbering them in succession. Oftentimes several areas may be traced on the same series of maps.

4. From a study of your results find (*a*) the average velocity, (*b*) direction, (*c*) path of all these areas.

### EXERCISE LVI

### To predict the Weather for Twenty-Four Hours ahead of the Date of the Map furnished you

1. Recall what you have learned about the rate and direction of movement and the path of low areas. (The movement of high areas is similar.)

2. Determine what you think the rate and direction of movement of the areas west and southwest of your location will be. In case you have two or more maps of consecutive days, you will get some suggestion by noting what the movement of the areas has been for the previous day or days. Now suppose these areas to move a day's journey, carrying with them about the same meteorological conditions; or, what would amount to nearly the same thing, suppose you travel from your home a day's journey for the area, in the direction from which the area is moving. Predict what the weather at your locality will be at the end of twenty-four hours as regards (*a*) direction of winds, (*b*) cloudiness and precipitation, (*c*) change in temperature, (*d*) change in pressure.

3. From the map of the next day copy the conditions found at or near your locality. Compare your predictions with them. Examine the maps again and determine whether the errors in your predictions were due to failure on your part to correctly apply your knowledge of the laws which you have studied, or were due to your ignorance of other laws.

## DATA FOR WEATHER MAP OF UNITED STATES

| | Temperature | Wind Direction | Pressure | Weather |
|---|---|---|---|---|
| Sidney, C.B.I. | 26 | SW | 29.54 | Cloudy |
| Father Point, Que. | 1 | NW | 29.56 | Cloudy |
| Chatham, N.B. | −2 | W | 29.59 | Clear |
| Halifax, N.S. | 14 | W | 29.72 | Cloudy |
| Yarmouth, N.S. | 19 | W | 29.82 | Cloudy |
| Quebec, Que. | −9 | W | 29.87 | Cloudy |
| Montreal, Que. | −9 | E | 39.98 | Clear |
| Eastport, Me. | 2 | W | 29.80 | Clear |
| Portland, Me. | 5 | NW | 29.84 | Clear |
| Boston, Mass. | 10 | W | 29.92 | Clear |
| Albany, N.Y. | 5 | NW | 30.08 | Clear |
| New York, N.Y. | 14 | NW | 30.07 | Clear |
| Philadelphia, Pa. | 15 | N | 30.07 | Clear |
| Washington, D.C. | 21 | NW | 30.06 | Clear |
| Lynchburg, Pa. | 26 | NE | 30.00 | Cloudy |
| Norfolk, Va. | 31 | NE | 29.98 | Clear |
| Charlotte, N.C. | 32 | E | 29.85 | Cloudy |
| Hatteras, N.C. | 40 | NE | 29.96 | Cloudy |
| Wilmington, N.C. | 38 | N | 29.85 | Cloudy |
| Charleston, S.C. | 45 | E | 29.79 | Cloudy |
| Augusta, Ga. | 39 | NE | 29.79 | Cloudy |
| Savannah, Ga. | 38 | E | 29.71 | Cloudy |
| Jacksonville, Fla. | 55 | SE | 29.71 | Rain |
| Key West, Fla. | 70 | S | 29.83 | Cloudy |
| Atlanta, Ga. | 38 | E | 29.71 | Rain |
| Pensacola, Fla. | 52 | NW | 29.54 | Cloudy |
| Montgomery, Ala. | 47 | NE | 29.50 | Rain |
| Vicksburg, Miss. | 15 | NW | 29.92 | Cloudy |
| New Orleans, La. | 33 | W | 29.80 | Cloudy |
| Fort Smith, Ark. | −6 | N | 30.24 | Cloudy |
| Little Rock, Ark. | 2 | W | 29.94 | Cloudy |
| Galveston, Tex. | | NW | 30.26 | Clear |

DATA FOR WEATHER MAP OF UNITED STATES (*continued*)

| | Temperature | Wind Direction | Pressure | Weather |
|---|---|---|---|---|
| San Antonio, Tex. | 11 | N | 30.37 | Clear |
| Shreveport, La. | 4 | W | 30.18 | Cloudy |
| Memphis, Tenn. | 14 | NW | 29.70 | Snow |
| Chattanooga, Tenn. | 31 | NE | 29.69 | Snow |
| Nashville, Tenn. | 31 | E | | Snow |
| Knoxville, Tenn. | 31 | E | 29.72 | Cloudy |
| Louisville, Ky. | 24 | NE | 29.74 | Cloudy |
| Indianapolis, Ind. | 17 | E | 29.80 | Cloudy |
| Cincinnati, O. | 17 | NE | 29.83 | Cloudy |
| Columbus, O. | 13 | E | 29.95 | Clear |
| Pittsburg, Pa. | 14 | NE | 30.02 | Clear |
| Rockliffe, Ont. | −16 | NW | 30.18 | Clear |
| Port Arthur, Ont. | − 7 | | 30.43 | Fair |
| Parry Sound, Ont. | −16 | N | 30.28 | Clear |
| Saugeen, Ont. | 1 | NE | 30.25 | Cloudy |
| Oswego, N.Y. | 0 | SE | 30.14 | Snow |
| Buffalo, N.Y. | 6 | NE | 30.14 | Cloudy |
| Kingston, Ont. | − 8 | N | 30.17 | Clear |
| Erie, Pa. | 11 | SE | 30.08 | Cloudy |
| Cleveland, O. | 14 | E | 30.01 | Clear |
| Toledo, O. | 13 | NE | 30.02 | Cloudy |
| Alpena, Mich. | 3 | SE | 30.27 | Cloudy |
| Marquette, Mich. | 6 | S | 30.27 | Snow |
| Grand Haven, Mich. | 12 | E | 30.07 | Cloudy |
| Port Huron, Mich. | 5 | E | 30.09 | Fair |
| Milwaukee, Wis. | 21 | E | 30.01 | Snow |
| Chicago, Ill. | 22 | NE | 29.96 | Cloudy |
| Duluth, Minn. | 2 | NW | 30.27 | Snow |
| St. Paul, Minn. | − 9 | W | 30.26 | Fair |
| La Crosse, Wis. | 8 | N | 30.10 | Snow |
| Davenport, Iowa | 15 | N | 29.98 | Snow |
| Des Moines, Iowa | −13 | N | 30.21 | Snow |
| Keokuk, Iowa | − 2 | NW | 30.01 | Snow |

DATA FOR WEATHER MAP OF UNITED STATES (*continued*)

| | Temperature | Wind Direction | Pressure | Weather |
|---|---|---|---|---|
| Springfield, Ill. | 20 | N | 29.83 | Snow |
| St. Louis, Mo. | 17 | NW | 29.84 | Snow |
| Cairo, Ill. | 26 | N | 29.66 | Snow |
| Kansas City, Mo. | −14 | N | 30.29 | Cloudy |
| Omaha, Neb. | −20 | N | 30.42 | Cloudy |
| Huron, S.Dak. | −30 | NW | 30.62 | Clear |
| Yankton, S.Dak. | | NW | 30.55 | Clear |
| Moorhead, Minn. | −27 | N | 30.58 | Cloudy |
| St. Vincent, Minn. | | NW | 30.68 | Clear |
| Bismarck, N.Dak. | −35 | N | 30.65 | Clear |
| Williston, N.Dak. | −36 | W | 30.98 | Clear |
| Havre, Mont. | −16 | E | 30.61 | Cloudy |
| Helena, Mont. | − 7 | N | 30.46 | Snow |
| Cheyenne, Wyo. | | N | | Clear |
| Salt Lake City, Utah | 4 | SE | 30.58 | Clear |
| North Platte, Neb. | −20 | NW | 30.46 | Clear |
| Denver, Col. | −18 | SW | 30.24 | Clear |
| Pueblo, Col. | −17 | W | 30.38 | Clear |
| Dodge City, Kan. | −15 | NW | 30.41 | Clear |
| El Paso, Tex. | 18 | NE | 30.32 | Clear |
| Yuma, Ariz. | 44 | N | 30.29 | Clear |
| Santa Fé, N.Mex. | − 5 | NE | 30.27 | Clear |
| Winnemucca, Nev. | 12 | NE | 30.48 | Clear |
| Spokane, Wash. | 5 | | 30.37 | Clear |
| Seattle, Wash. | 38 | SE | 30.29 | Clear |
| Roseburg, Ore. | 32 | NE | 30.24 | Fair |
| Los Angeles, Cal. | 45 | NE | 30.17 | Clear |
| Red Bluff, Cal. | 34 | NE | 30.29 | Clear |
| Eureka, Cal. | 43 | SE | 30.16 | Fair |
| Sacramento, Cal. | 37 | NW | 30.26 | Clear |
| San Diego, Cal. | 44 | NE | 30.12 | Clear |
| Minnedosa, Manitoba | −39 | NW | 30.89 | Clear |
| Winnipeg, Manitoba | −34 | N | 30.74 | Clear |

## EXERCISE LVII

### To construct a Weather Map (*see Appendix A*)

1. From the data given in the table, copy on the blank weather map, form *D*, the temperature and pressure for each place, putting the first just above and the second just below the dots showing the location of the cities.

2. *Isobars.* Use a blue pencil. First draw the isobar of 30 inches,—that is, connect all points having a pressure of 30 inches. Very few places will be found with a reading of 30, but other places between those given on the map are to be found having this pressure. If one station has a reading of 30.05 and the next one to it a reading of 29.95, we assume that the pressure gradually decreases in passing from the first to the second, and that at a point halfway between will be just 30. Find two adjacent places on the Atlantic coast such that one has a pressure greater than 30 inches and the other less than this. The isobar of 30 inches will pass between these two cities, which are Washington, with a pressure of 30.06 inches, and Norfolk, with a pressure of 29.98 inches. The line will pass nearer Norfolk than Washington. The difference between the two readings is .08, while the difference between the reading at Norfolk and the 30-inch isobar is .02. As .02 is one fourth of .08, the isobar will be one fourth of the distance from Norfolk to Washington. Extend the line about $\frac{1}{2}$ inch eastward and mark it 30. Then extend the line in the other direction, noting the suggestion that when you do not find a reading of 30 the line must pass between two stations, such that the reading of one is higher and of the other lower than the isobar that is being drawn. For instance, after drawing the line through Lynchburg it cannot pass between Columbus and Cincinnati, as the readings

here are both lower than 30; and it cannot pass between Washington and Pittsburg, for the readings here are both higher than 30. Continue this line till it reaches the edge of the map, taking care to space properly its position between each pair of stations. Begin the isobar of 30.1 inches, which will start on the Canadian border, and continue it, using the same principles as in the previous case. Then draw isobars for every tenth of an inch till the highest pressure on the map is reached. Then begin with the isobar for 29.9 inches and draw the others till the lowest pressure is reached. These isobars cannot cross one another. Find the high and low areas and mark them.

3. *Isotherms.* These are to be drawn on the same map as the isobars. The principle used in making isotherms is the same as that just used in making isobars, except that the isotherms are made for every ten degrees. Use a red pencil and make the lines dotted instead of continuous. Begin with the highest temperature divisible by 10, which in this case is 70. Make the isotherms for every ten degrees till the lowest temperature is reached. Mark each line as soon as you begin to draw it.

4. *Weather.* Near each station place a small circle and represent the state of weather as follows: ○ clear, ◑ fair or partly cloudy, ● cloudy, Ⓡ rain, Ⓢ snow.

5. *Wind.* Draw arrows through these circles to indicate the direction of the wind, allowing them to fly with it. If the wind were northwest the arrow would point thus: ↘

6. *Precipitation.* Under each station which reports rain or snow draw a green dash. Draw a line so as to inclose all these places. The scattering reports of precipitation which are separated by some distance from the other stations giving reports of rain or snow may be ignored. Color

lightly with green the area within this line to show the regions of precipitation.

7. *Cloudiness.* Under each station which reports the weather as cloudy draw a yellow dash. Draw a line so as to inclose these stations, ignoring as before the scattering observations. Color this area, except the part already tinted green, very lightly with yellow, to show regions of cloudiness. What relation does this region bear to the region of precipitation?

8. In the blank space on the lower half of the map write a weather prediction, as regards temperature, wind, and state of weather, for the next twenty-four hours for your locality.

# CHAPTER IV

## THE OCEAN (*see Appendix A*)

### EXERCISE LVIII

### To make a Profile of the Bottom of the Atlantic Ocean and Adjoining Land

The figures in the table give approximately for certain distances from the coast the heights above and depressions below sea level, along the line extending from the Appalachian Mountains in Pennsylvania eastward for several hundred miles into the ocean. Draw a straight line to represent sea level. Two inches from the left end of the line make a dot to represent the location of the 0 in the table. Measure off from this point toward the left the first two distances on the scale of 1 inch to 75 miles, and toward the right the remaining distances. Represent elevations by distances above the line and depressions by distances below it, on the scale of 1 inch to 16,000 feet. Mark the distances by dots, which are to be connected by a smooth line. Label that part of the ocean bottom within the 600-foot limit

| Distance from Coast | Height above Sea Level |
|---|---|
| 150 miles | 1,500 feet |
| 75 " | 500 " |
| 0 " | 0 " |
| | Depth below Sea Level |
| 75 " | 600 feet |
| 100 " | 6,000 " |
| 225 " | 15,000 " |
| 325 " | 18,000 " |
| 400 " | 18,000 " |

"continental shelf." As you look at the profile on either side of this distance, of which does it seem to be a part, the land or the ocean bottom?

### EXERCISE LIX

### Ocean Currents

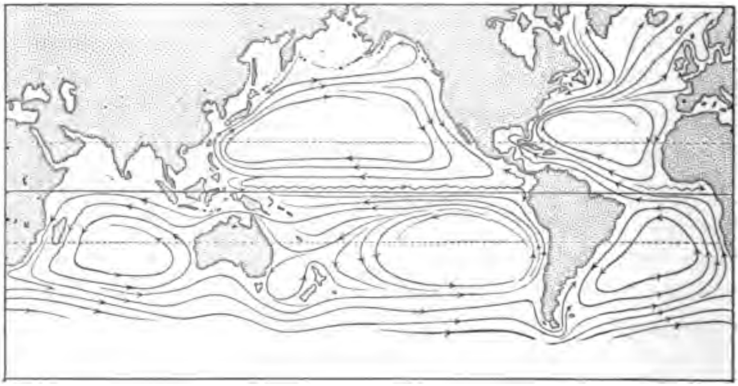


FIG. 10. CHART OF OCEAN CURRENTS

1. How many systems of currents do you find in Fig. 10? Describe the location of each. What part of the oceans is not involved in this movement? Where is the largest current situated? How do the others compare with each other in size?

2. In what ways are the currents alike? In what ways do they differ?

3. What is their direction along the equator?

4. Compare the general courses of the winds in Figs. 8 and 9 with the courses of the ocean currents. What relation between winds and currents is suggested?

5. Make a rough sketch of the currents and outlines of the continents, as shown in Fig. 10.

6. How many currents do you find in the north Atlantic? Write a description of their paths. How will the temperature of the various parts of the north Atlantic be affected by these currents? How will this affect the neighboring lands?

### EXERCISE LX

### Shore Lines

*a. A Young Coast: Boothbay Sheet, Me.*

1. Describe the principal land features shown here.
2. Describe the principal water features.
3. If the land were to be submerged 100 feet, then the 100-foot contour would be the shore line. How does the outline of this contour compare in general character with the present coast? What is thus suggested regarding the manner in which the present coast has been formed?
4. Beginning at the top of a new page, make a rough outline of the coast line, including the islands, on a reduced scale. Leave the rest of the page for the next two exercises.

*b. An Adolescent Coast: Barnegat Sheet, N.J.*

1. What is the relation of Island Beach to the shore line of the mainland as regards position and direction? Describe its appearance as regards length, width, and height. How was it formed?
2. What is inclosed behind the bar? In times of storms how would this water compare with that on the outside of the bar?
3. What are forming on each side of this bay? What may result eventually if these continue to form?
4. What do you find situated along the outer shore of Island Beach?

5. Compare the inner and outer shores of Island Beach and account for the difference.

6. What change in elevation has occurred on the shore line of the mainland, as shown by the rivers? What is the evidence?

7. Just below the sketch of the Maine coast draw an outline of the New Jersey coast, using two lines, one for the outer shore of Island Beach and one for the mainland.

### *c. A Mature Coast: Provincetown Sheet, Mass.*

1. Describe the outer coast of Cape Cod. What is its vertical form from Highland Light southward?

2. What kind of a formation do you find inclosing Provincetown harbor? How was this formed and whence was the material for its construction derived?

3. How many harbors do you find on the outer coast? For how long a distance is this true? What do you find located along the coast? How far apart are they?

4. What explanation would you give of the presence of the pond beside Moon Pond meadow?

5. Just below the sketch of the New Jersey coast draw an outline of the coast of Cape Cod.

6. How do the outlines of the three kinds of coast lines compare? Which shows evidence of the greatest amount of wave action? Which of the least? Give reasons for your answers. What is the effect on the shore line of long-continued wave action, as suggested by these maps?

7. For illustrations of the action of waves on lake shores, see plates facing pages 75, 86, 94, 100, 106, 110 in the *Fifth Annual Report of the United States Geological Society*. See also, in the *Eighteenth Report*, plates facing pages 542 and 544.

# APPENDIX A

## SUGGESTIONS TO TEACHERS

### THE WORLD AS A GLOBE

*Exercise II.* This will require a clear day, and doubtless several attempts will be necessary before a sufficient number of observations can be taken in one day. Three observations are sufficient to determine the plane, but if a larger number is taken there is less opportunity for error. The advantage of this method is that it may be used at any time of the year.

As alternative methods, the latitude may be determined by measuring the altitude of the North Star, or by finding the zenith distance of the sun at noon at the time of either equinox.

*Exercise V.* The most satisfactory results may be obtained if this is performed in a dark room with a lamp to represent the sun; but as this cannot generally be done in the school building, this exercise may first be worked out as suggested in daylight, and then its lessons will become more firmly fixed if the pupil repeats the exercise at home in the evening.

### THE LAND

*Exercise VIII.* Before any satisfactory work with topographic maps can be done, it will be necessary for the pupil to acquire a clear understanding of the meaning of the contour lines. This preliminary exercise has been found well worth the preparation and time required. One model will be sufficient for the whole class, and doubtless some of the boys can be called upon to aid in constructing it. In Hodge's *Nature*

*Study and Life* will be found directions for making a tank for an aquarium which will serve very nicely for this exercise. It will be better to have the class meet in small divisions. The contour interval will need to be changed to suit the size of the model. The pupils must be watched carefully while drawing the lines, to see that they are placed at the proper distances from the edge of the paper.

If a map of your own locality has been issued, the use of this will doubtless create more interest both in this exercise and the next one; but if none has been issued, any other map which shows some diversity of hills and valleys may be selected.

*Exercise IX.* In preparation for this exercise lines should be drawn on the maps where the profile is to be made. This profile should cross some streams and hills, and the cross lines, which should be numbered, should be placed so as to best bring out these various features.

*Exercise XI.* In place of the Wicomico sheet almost any other sheet which exhibits some diversity of slope may be used.

*Exercises XII–XXXVIII.* In connection with these exercises the question will naturally arise regarding their relation to the text-book, Shall they follow or precede it? In considering this question there is one well-grounded principle which should be kept in mind, namely, that the kind of laboratory work which will be of greatest benefit to the pupil is that which leads to the most original observation and thinking and not merely to verification. When it is largely a matter of accurate observation, as in botany, the subject would be robbed of a large amount of its value were the text-book discussion to precede the laboratory work. On the other hand, in some experiments in physics the principles involved are so complicated that some explanation and study of these may be needed previous to the laboratory work. Shall physical geography be classed from this standpoint with botany or with physics? I have found that the difficulties encountered

by the student are not due to any lack of understanding of the principles discussed in the text-book, but to failure to read the map correctly. If such is the case, it is evident that the remedy lies in having the study of land forms by means of maps preceded not by text-book discussion but by more thorough preliminary training in the use of maps. A student who has studied the text-book previous to taking up the laboratory work is apt, even though it be unconsciously sometimes, to answer the questions given him as much from his recollection of what he has read as from direct observation of the map. Under such conditions the very purpose of the laboratory exercises is defeated.

To correct any mistaken idea that the pupil may acquire concerning the size of the types of land studied by means of a single sheet, which represents only a small part of the whole area representing a type, it is well to have a larger map made by pasting together contiguous sheets. To do this the margin of one sheet may be cut off and the sheets brought together till the proper lines and roads, etc., meet, and then they may be fastened together by means of paste on the uncut margin. The top of the map may be backed with cloth and then attached at this edge to a wooden roller. This same plan may be used with the map of the alluvial valley of the Mississippi River.

Professor Davis, in the *Journal of School Geography*, Vol. III, No. 5, has suggested the following examples of grouped topographic sheets.

The Allegheny ridges of middle Pennsylvania: Sunbury, Shamokin, Catawissa, Millersburg, Lykens, Pine Grove, Harrisburg, Hummelstown, and Lebanon sheets.

The drowned valleys of the coastal plain of Maryland: Brandywine, Prince Frederick, Sharps Island, Wicomico, Leonardtown, Drum Point, Mount Ross, Piney Point, and Point Lookout sheets.

The dissected plateau of West Virginia: Charlestown, Kanawha Falls, Nicholas, Oceana, Raleigh, and Hinton sheets.

The drumlin district of southern Wisconsin: Madison, Sun Prairie, Waterloo, Evansville, Stoughton, Koskonong, and Whitewater sheets.

The canyon of the Colorado: St. Thomas, Mount Trumbull, Kaibab, Echo Cliffs, Camp Mojave, Diamond Creek, Chino, and San Francisco mountain sheets, Arizona.

In a number of cases references are given to standard works which contain photographs of the land form under discussion. These may easily be supplemented by other pictures which may be gradually collected. The effort to acquire such a collection is well worth while, as these pictures will tend to correct any mistaken idea that the pupil may have obtained from the study of the map, and will strengthen the correct ideas.

## FIELD WORK

*Exercises XLII–XLIV.* These do not include all that should be done in the field. This line of work depends so much on local conditions that only a few general exercises are given, which should be supplemented by such others as each locality will best allow. In order to derive the most benefit from these field trips it is essential that there should be placed in the hands of the pupil special directions which shall give him definite questions to answer and definite problems to solve. Otherwise much time will be wasted and the value of the trips lessened.

## THE ATMOSPHERE

*Weather observations.* Arrangements should be made so that each member of the class may make individual readings of each instrument for some part of the year, while the observations on the wind and clouds may be carried on by each individual for a longer time. It will be necessary for the teacher to keep a record of his own, so that he may correct the errors of the pupils and make the following exercise on the representation of the conditions of the month more reliable. The

correlation of these various conditions may be compared with the observations made on the weather maps, which, of course, will furnish the basis for the more reliable conclusions. These weather observations should be begun early in the course, so that each pupil may get as much experience as possible in reading the instruments and in keeping records.

*Exercise LVII.* The work on weather maps may be extended almost indefinitely. If one has time, the construction of a weather map may be preceded by more detailed practice in the making of isotherm and isobar maps on separate sheets, the lines of which may be transferred to one sheet on which a complete weather map is to be made.

### THE OCEAN

If one is situated near the coast, plans should be made to carry on observations on the tides, as suggested in Gilbert and Brigham's *Teachers' Guide and Laboratory Exercises.*

# APPENDIX B

## MATERIAL NEEDED FOR THE WORK OUTLINED

### UNITED STATES TOPOGRAPHIC MAPS

Echo Cliffs, Arizona; Alturas, Modoc Lava Beds, Shasta, Shasta Special,[1] California; Canyon City, Huerfano Park, Colorado; Marion, Iowa; Caldwell,[1] Kansas; Donaldsonville, Louisiana; Boothbay,[1] Maine; Chesterfield, Provincetown, Springfield, Massachusetts; Livingston, Montana; Barnegat, Glassboro, New Jersey; Mount Taylor,[1] New Mexico; Fargo,[1] North Dakota; Crater Lake Special,[1] Oregon; Harrisburg,[1] Pennsylvania; Abilene, Texas; Henry Mountains, Utah; Harper's Ferry, Virginia, West Virginia, and Maryland; Charleston,[1] West Virginia; Eagle,[1] Sun Prairie, Wisconsin.

These maps may be obtained by addressing Director, United States Geological Survey, Washington, D.C. The price is 5 cents a sheet, but if bought in quantities of one hundred or more, it is 2 cents each.

*Topographic Atlas of the United States, Physiographic Types.* Folios I and II, 25 cents each; Folio III, 50 cents. These may be obtained from the same address as above. Map of the alluvial valley of the Mississippi River, consisting of eight sheets, may be obtained by application to Secretary, Mississippi River Commission, St. Louis, Mo. $1.00 for the set; 20 cents a single sheet.

### WEATHER MAPS

The daily weather maps may usually be obtained by asking the Chief of the Weather Bureau, Washington, D.C., to have

[1] Included in Folios I and II of *Physiographic Types*, referred to below.

them sent from the nearest station, stating that they are to be used for school purposes and will be posted in a public place.

A supply of the blank weather maps, forms *D* and *DD*, will be needed. Apply to Chief of Weather Bureau, as above. A price of about 20 cents per hundred is set on these, but sometimes they are sent free when it is understood that they are to be used for school purposes.

### INSTRUMENTS FOR STUDY OF THE ATMOSPHERE

The lists of instruments which I have seen refer to those used by the weather bureau, and so are expensive, but I have obtained cheaper instruments which have proved satisfactory for school purposes, while making some saving of expense. These were obtained from L. E. Knott & Co., Boston, whose prices are those given first after the various instruments. Doubtless these may also be obtained from other dealers in scientific supplies for about the same prices. The more expensive pieces referred to above may be obtained from H. J. Green, Brooklyn, whose prices are given second in the list below.

| | | |
|---|---|---|
| Mercurial barometer . . . . . . | $5.75 | $30.00 |
| Thermometer . . . . . . . . . . | 1.00 | 2.75 |
| Rain gauge . . . . . . . . . . | 3.25 | 5.25 |
| Maximum and minimum thermometers | 1.50 | 6.25 |

Wind vane: the price of this as given by Green is $10.00, but one can doubtless find a vane in the vicinity of the school building which may be used for the purposes of the class.

### GLOBES

A small globe should be furnished each of the pupils for the exercise on the seasons. Globes suitable for this purpose may be obtained from dealers in school supplies at a cost of 25 cents each or less.

Altogether the cost of the material needed for a class of fifteen will be about $30.00, exclusive of specimens of rocks and minerals. School collections of these may be obtained very

reasonably of E. E. Howell, 612 17th Street, N.W., Washington, D.C. Collection No. 1 contains 20 minerals and 20 rocks; No. 2, 40 minerals; No. 3, 40 rocks; price of each collection $2.00. The most desirable condition is to furnish as many sets of rocks and minerals as there are pupils in the class, but satisfactory work can be done with a smaller number.

While a systematic study of rocks and minerals belongs to geology rather than to physical geography, at least one collection should be furnished for general use. The collections previously mentioned will serve this purpose; but if only a single set of specimens is to be obtained, it will be better to secure a more elaborate school collection. This may be obtained of Mr. Howell, and also of the following: The Foote Mineral Co., 1317 Arch Street, Philadelphia, Pa.; Ward's Natural Science Establishment, Rochester, N.Y.; Mr. George B. Frazar, West Medford, Mass.

# APPENDIX C

## LIST OF BOOKS AND MAGAZINES GIVING SUGGESTIONS CONCERNING LABORATORY AND FIELD WORK

*The Use of Government Maps in Schools.* Davis, King, and Collie. Henry Holt & Co. 35 cents.

*Physical Geography* and *Elementary Physical Geography.* Davis. Ginn & Company.

*Elementary Physical Geography.* Tarr. Macmillan & Company.

*Lessons in Physical Geography.* Dryer. American Book Company.

*Practical Exercises in Elementary Meteorology.* Ward. Ginn & Company.

Report of Committee on College Entrance Requirements, appointed by the National Educational Association, may be obtained of Dr. Irwin Shepard, Winona, Minn. 25 cents.

Bulletins 2 and 7, High School Department, University of the State of New York, contain reports of the proceedings of the third and fourth annual conferences of the New York State Science Teachers Association. These may be obtained by addressing the Regents, University of the State of New York, Albany. 25 and 35 cents

Document No. 16 of the College Entrance Examination Board. Address the Board at Post Office Substation 84, New York, N.Y. 10 cents.

*Teacher's Guide to accompany Elementary Physical Geography.* Davis. Ginn & Company.

*Teachers' Guide and Laboratory Exercises* to accompany *An Introduction to Physical Geography.* Gilbert and Brigham. D. Appleton & Co. Sent free to teachers.

*Field and Laboratory Exercises in Physical Geography.* J. H. Chamberlain. American Book Company.

*A Laboratory Manual for Physical Geography.* Chicago Teachers. Atkinson & Mentzer.

The following articles are found in the *Journal of School Geography,* which may be obtained of J. L. Hammett & Co., Boston, for 15 cents a number.

"Laboratory Work in Elementary Physiography." Cornish. Vol. I, Nos. 6 and 7.

"Topographic Maps of the United States." Davis. Vol. I, No. 7.

"Elementary Meteorology." Jameson. Vol. II, Nos. 1, 2, 3, and 4.

"The Equipment of a Geographical Laboratory." Davis. Vol. II, No. 5.

"Equipment of a Meteorological Laboratory." De C. Ward. Vol. III, No. 7.

"Some Suggestions for Excursions with Elementary Classes." Emerson. Vol. III, No. 8.

"Geographical Laboratory Work in Worcester Academy, Mass." Snyder. Vol. III, No. 10.

"Weather Map Exercises." Jefferson. Vol. V, No. 2.

"Map Notices." Vol. V, No. 3.

"Exercises on United States Topographical Maps." Blount. Vol. V, No. 4.

"Maps of the Mississippi River." Davis. Vol. V, No. 10.

The three following articles were published in the *Bulletin of the American Bureau of Geography,* of which the editor was Professor E. M. Lehnerts, Winona, Minn. Price per number, 35 cents.

"Laboratory Work in Physiography." Kummel. Vol. I, No. 1.

"Modeling Mt. Shasta." Holway. Vol. I, No. 3.

"Experiences in Field Work." Wood. Vol. II, No. 1.

"Field Work in Physical Geography." Davis. *Journal of Geography*, Vol. I, Nos. 1 and 2. J. L. Hammett & Co. New York and Boston. 20 cents a copy.

"Training Teachers for the Study of Home Geography." Emerson. *Journal of Geography*, Vol. I, No. 9.

"The Place of Field Work in High School Physiography." Goodrich. *School Science*, Vol. I, No. 5. 740 Cullom Avenue, Chicago. 25 cents a copy.

"Field Work in Geology and Physical Geography." Tarr. *The School Review*, Vol. V, No. 8. University of Chicago. 20 cents a copy.

"Geography in the Horace Mann Schools." Dodge & Kirchwey. *Teachers College Record*, Vol. II, No. 2. Macmillan Company, New York. 20 cents a copy.

"An Outline of Eight Excursions for the Study of the Physical Geography and Geology of Springfield and Vicinity." Orr. Springfield Geological Club. 10 cents a copy.

"The Fields of Brockton. Notes for Field Study in Geography and Geology." Jefferson.

In the *Teachers Manual* to accompany Brigham's *Text-Book of Geology* will be found many valuable suggestions concerning field work.

# APPENDIX D

## LISTS OF LABORATORY EXERCISES

### I. GIVEN BY CORNISH IN THE *JOURNAL OF SCHOOL GEOGRAPHY* June, 1897

1. Construct a diagram which shall represent some of the facts of the solar system, including (1) relative distances of the planets from the sun; (2) their sizes relative to each other and to the disk of the sun, and (3) their satellites. Two days.

2. On the same sheet, which is about 80 inches by 18 inches, construct a diagram to show (1) the inclination of the earth's axis to the plane of its orbit, (2) its perihelion and aphelion positions, and its position at the equinoxes and solstices. Two days.

3. Measurement of the sun's altitude by means of the clinometer.

4. Plot curves to show the daily maximum, minimum, and average temperature, the barometric pressure, and the rainfall from records kept by the student for the month of December. Two days.

5. Determine the dew point and relative humidity.

6. Illustrate the constituents of the atmosphere, — (1) dust, (2) water vapor, (3) carbon dioxide, (4) oxygen, (5) nitrogen (teacher's experiment). One day.

7. Construct a map showing the drainage slopes of the United States. One day.

8. Preliminary study of a topographic map. Three days.

9. Study of a coast survey or lake survey map. Two days.

10. Study of a Washington weather map. One day.

11. Study of the north Atlantic chart. Two days.

12. Construction of a weather map from facts published in the daily papers. Two days.

13. Construction of a river profile from source to outlet by the aid of topographic maps. Two days.

14. Construction of a profile around the earth at the equator, showing ocean beds and continental areas. Two days.

15. Study of common minerals and rocks. Six weeks.

16. Detailed study in the field of a miniature river valley, with measurements of width, length, number of turns, branches; directions taken with compass and notes made of the same. One day.

17. Construction of a topographic map of the valley surveyed above (16), on a scale of 50 feet to 1 inch, with contour lines at 5-foot intervals. One day.

18. Study of typical topographic features with their various modified forms by means of selected sheets of the various government and state surveys. Eight days.

19. Excursions to several points of interest, including a sand bank of glacial origin, a sand dune, a limestone quarry.

20. Several stereopticon exhibitions of pictures illustrating (1) facts of astronomy and the earth's relations as a planet, and (2) typical physiographic features.

### II. SUGGESTED BY THE COMMITTEE ON PHYSICAL GEOGRAPHY IN THE REPORT OF COMMITTEE ON COLLEGE ENTRANCE REQUIREMENTS[1]

Cause of day and night, and extent of sunlight over surface (1).

Determination of latitude, north and south line, and high noon (1).

Determination of difference of longitude by sending watch (1).

Finding variation of local and standard time (1).

[1] Figures in parentheses indicate the number of hours for each exercise.

Making maps on different projections (4).

Study of ocean-current maps (1).

Study of tide charts (1).

Study of map of the world, showing heights of land and depths of sea (2).

Difference in temperature between the top and bottom of a hill (1).

Finding height of hill or building by barometer (1).

Determination of dew point (1).

Making isotherm and isobar maps from furnished data (4).

Study and reproduction of weather map (1).

Predictions from weather maps (written with reasons) (2).

Observations of rainfall, temperature, velocity of the winds, etc.

Determination of the amount of snowfall and the amount of water produced by an inch of snow (1).

Observations of ground temperatures, depths of frost, etc.

Making contour and hachure maps from small models (2).

Drawing cross sections from contour maps (4).

Written descriptions of models (4).

Picture reading (written description) (4).

Reproduction of contour map in hachures (1).

Making map of small area in neighborhood (1).

Planning of journey, with study of country to be seen (4).

Determination of the amount of sediment carried by a stream (1).

Study of rocks and minerals (10).

Study of erosion with sprinkling pot (2).

In fall, four excursions, one a week (8).

Four excursions in spring (8).

## III. LIST OF POSSIBLE EXERCISES GIVEN BY THE COLLEGE ENTRANCE EXAMINATION BOARD

As a part of the candidate's preparation the following is required by the Board.

"Individual laboratory work, comprising at least forty exercises selected from a list not very different from the one given below. From one third to one half of the candidate's class-room work should be devoted to laboratory exercises. In the autumn and spring field trips should take the place of laboratory exercises."[1]

*World as a Globe.*

Construct a diagram showing inclination of earth's axis, and effects of an axis at right angles and parallel to plane of orbit (1).

Cause of day and night, and extent of sunlight over surface (1).

Construct a diagram showing position of earth, moon, and sun at the several phases of the moon (1).

Construct a series of lines to some adopted scale, showing circumference and diameter of earth and distance of several leading cities from New York (1).

Determination of latitude, north and south line, and high noon (1).

*Ocean.*

Study of ocean-current maps (1).

Study of tide charts (1).

Study of types of shore lines (2).

Study of positions of lighthouses, life-saving stations, and large cities in relation to southern Atlantic shore (1).

Study of map of world showing heights of land and depths of sea (1).

Explain selected steamer routes across Atlantic and Pacific (1).

[1] Numbers in parentheses indicate the value that should be given in estimating the total number of forty.

*Atmosphere.*

Determination of altitude of hill by barometer (1).

Determination of dew point (1).

Comparison of January and July temperatures at 40° N. and S. Lat. (2).

Location and migration of heat equator and cold pole (2).

Comparison of temperature over land and water at different seasons (2).

Study distribution of wind systems by seasons, and compare with pressure conditions (2).

Make isotherm and isobar maps from furnished data (2).

Find average wind directions about a storm center (1).

Making of complete weather maps from furnished data (2).

Study distribution of cloudiness and rainfall about a storm center (1).

Predict weather conditions from data furnished (1).

Find average rate and direction of motion of storm centers (1).

Study of condition of "cold waves" and "northeasters" (1).

*Land.*

Comparison of areas to scale (1).

Making cross sections of contour maps to scale (4).

Cross section of hachure map, and changing hachure to contour map (2).

Writing description of models (4).

Writing description of pictures and accompanying map (2).

Construction of river profile (1).

Making drainage map of United States (1).

Written description of selected maps illustrating classes of land forms (4).

Planning a journey and describing country to be seen (1).

Locating illustrations of common land forms on some special contour map (1).

Four excursions in autumn, described in detail (8).

Four excursions in spring, described in detail (8).